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A NEW METHOD OF COPPER SULPHATING RESERVOIRS

By R. F. Goudey
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Copper sulphate was first used in reservoirs to kill algal growths by Moore in 1901, as described by Moore and Kellerman in 1904 (1). They discovered that various microscopic organisms causing trouble in reservoirs could be killed with concentrations of copper sulphate suited for each specific organism and that the dosages of copper sulphate had to be corrected for temperature, alkalinity, organic matter and carbon dioxide of the water to be treated. Their method of applying copper sulphate was that of placing coarse crystals of copper sulphate in burlap sacks and dragging them alongside a boat so as to systematically cover the surface of the water being treated. Subsequently, there has been no important technical contribution in the matter of necessary corrections to basic killing doses for specific organisms nor has there been any attempt to evolve entirely new methods of application of the copper sulphate to reservoirs. True it is that Whipple (2) and Hale (3) have added information on the killing doses for organisms other than reported by Moore and Kellerman and have published valuable practical data in regard to the treatment of reservoirs but until the present time there has been no real challenge to the general method of treatment or of the application of the chemical.

Mention should be made of a number of minor improvements of the old procedure because it indicates that dissatisfaction with the old method is general. These changes do not overcome the inherent and fundamental objections of the old procedure but do serve to show a definite trend toward desired improvements. In large reservoirs power boats have replaced rowboats and speeds have been increased in power boats from 6–8 to 12–15 miles per hour. Booms have been installed on the boats to space sacks of copper sulphate farther apart. Double sacks are employed to slow up the dissolving of copper sulphate in the water. Supports have been provided to keep the burlap sacks open so that a uniform and regulated feed can be effected by use of ladles, scoops or hoppers. In some instances metal cages have been substituted for burlap sacks. There has been a definite tendency to specify smaller crystals of copper sulphate of pea size rather than large crystals of 2½-inch diameter which were formerly used because the flow of small crystals into dragging sacks can be more carefully regulated. Delivery of copper sulphate in 100 pound acid proof sacks instead of 450 pound drums has greatly aided in the handling of the chemical in storage, boat loading and in its application. There has been an almost universal adoption of boats lined on the inside to resist corrosion from the free acid in copper sulphate, and in providing hopper and improved loading facilities. Considerable experiments have been made in attempting to dissolve copper sulphate and feed it out as a solution in the wake of the boat or discharge it from spray nozzles over the surface of the water. So far, except for special cases, this method has not been found satisfactory for a large reservoir and is even more subject to the same fundamental objections as the present method.

In challenging the present procedure the author claims, first, that not sufficient work has been done to determine necessary corrections for temperature, carbonate and bicarbonate alkalinity, organic matter and wind action, at least so far as Southern California waters are concerned, second, that the depth to which treatment is carried should be carefully determined for each treatment, third, that the old method is too crude to apply uniform distribution of copper sulphate, particularly with minimum copper sulphate doses without great waste of material and particularly when it is desired to treat water at specific depths, fourth, that the chemical efficiency of the old method is low in that before the copper sulphate in soluble form can spread over the entire surface it either sinks or forms insoluble

compounds which in turn sink and render the action of copper sulphate useless, and finally that the old method is particularly laborious, time consuming and is not adapted to use during rough weather.

NEW METHOD

The new method of applying copper sulphate is that of spreading or scattering the copper sulphate in a fine crystalline form from a specially designed "scatterer" or by a suitably designed "blower" so that the entire reservoir surface can be uniformly covered with exact doses of copper sulphate in its dry form. If it is desired to treat just the top three feet of water only the smallest of crystals are used. If it is desired to treat down to 15 feet depths only the material passing a screen with 16-inch meshes to the inch is used. Even larger crystals have been employed to treat down to 100 feet depths. The smaller crystals passing the 16-inch mesh screen usually reach 4 feet depth before completely dissolving. The dry crystals immediately start dissolving as soon as they strike the surface, and the crystals of various sizes gradually dissolve as they settle through the water. In this manner every portion of the zone desired to be treated secures soluble copper in the required concentration. In this method copper sulphate can be spread from equipment mounted on the rear end of a boat, can be used on airplanes, may be stationed on the shore allowing the wind to blow the material over the reservoir or may be stationary over an aqueduct or a moving stream of water. Except for the use of aeroplanes experiments have been conducted on these different methods. While the general procedure is still in the development stage, it has already proven decidedly superior to the old method in that smaller doses can be effectively used with a considerable saving in labor, material and time of treatment. The decided advantages of the new method over the former procedure become self-evident as the disadvantages of the older method are carefully analyzed.

OBSERVATION OF THE OLD METHOD OF COPPER SULPHATE TREATMENT

When it comes to treating a given reservoir there is a wide divergence in practice which, actually, is a compromise between what the laboratory determines as theoretically necessary and what at the reservoir can be actually added from the practical standpoint. As previously stated, printed lists of copper sulphate concentrations necessary to kill specific organisms are available. However, these

are basic dosage rates and might be over 100 percent in error so far as local conditions are concerned. It is deplorable that no one has attempted to determine just what the copper doses should be for Southern California reservoirs, and it is still necessary to fall back on the corrections of Moore and Kellerman as published in 1904 which include: a 2.5 percent increase or decrease for each degree of temperature above or below 15 degrees Centigrade, a 2 percent increase for every ten p.p.m. of organic matter, a vague 0.5 to 5.0 percent increase for each 10 p.p.m. of alkalinity and an uncertain 5 percent increase when the carbon dioxide content is low.

Southern California has reservoirs in which the seasonal temperatures vary from 40–80 degrees Fahrenheit, and chemical contents fluctuate as follows: organic matter 10–20 p.p.m., carbonate alkalinity 0–60 p.p.m., bicarbonate alkalinity 100–150 p.p.m. and carbon dioxide content zero or nearly zero. At 40°F. the correction to be applied to the basic theoretical doses is 64 percent greater than that given by published data and at a temperature of 80° is 112 percent greater. Instead of using 0.1 p.p.m. to destroy Anabaena and Aphanizomenon it is necessary to use 0.16 p.p.m. in the winter and 0.21 p.p.m. in the summer. In order to kill Fragilaria the theoretical dose has to be raised from 0.25 p.p.m. to 0.40 or 0.53 p.p.m. depending upon the season. The stated dose for Coelosphaerium is 0.5 p.p.m. and this has to be increased to 0.8–1.01 p.p.m. The general practice here as elsewhere has been to neglect making any precise analysis of what the dosage should be and just to double the theoretical doses. This is at once seen to be but a crude approximation, although it is generally on the safe side. The failure in applying carefully determined doses for each treatment is really due to the inability of adding small amounts of required sulphate because of limitations later to be discussed and which have militated against any need to doing any better than just guessing. Yet, if not enough copper sulphate has been added the value of the treatment is lost. If the actual dosage is but 0.2 p.p.m. in error, it means that in a reservoir of 20,000 acre feet capacity $440 worth of copper sulphate has been wasted in a single treatment. Hence, the importance of knowing just what practical concentrations of copper sulphate are required for each treatment.

Even after the dosage rate is fixed, there is still no uniformity in determining the total volume of water entering the calculation for the total copper sulphate dose required. At Oakland a depth of

10 feet is at times used. At Los Angeles a depth of 15 feet is generally assumed. New York is said to employ at times a depth of 20–30 feet. San Francisco and elsewhere figure the entire volume of the reservoir. Some places use fixed doses regardless of the organism present and other variously correct theoretical dosages and apply it to volumes of water based on different depths of treatment. Why should this be unless it is an attempt to harmonize theoretical doses with what practically can be obtained?

TABLE 1

Record of copper sulphate feed at Los Angeles reservoirs; new and old methods

RESERVOIR	POUNDS $CuSO_4$		ACRES COVERED		POUNDS PER ACRE		DOSE, P.P.M. Top 3 feet		DOSE, P.P.M. 15 feet depth		ENTIRE	
	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New
Haiwee, No.		5,000		665		7.5		0.9		0.2		0.09
Haiwee, So.	10,000	10,000	860	1180	11.5	8.5	1.4	1.0	0.3	0.2	0.19	0.08
Fairmont	4,000	3,000	165	165	24.0	18.2	2.9	2.5	0.6	0.5	0.21	0.15
Bouquet	7,650	6,750	460	600	16.6	11.2	2.0	1.3	0.4	0.3	0.12	0.08
Dry Canyon	2,100		50		42.0		5.0		1.0		0.77	
Upper San Fernando	1,400		70		20.0		2.4		0.5		0.47	
Lower San Fernando	6,100	4,900	384	360	16.0	13.5	1.9	1.6	0.4	0.3	0.13	0.12
Chatsworth	9,000	6,000	510	510	17.5	11.7	2.1	1.4	0.4	0.3	0.50	0.33
Encino	1,600	1,500	80	80	20.0	18.7	2.4	2.2	0.5	0.4	0.17	0.17
Stone Canyon	4,500	2,000	115	110	39.0	18.2	4.7	2.2	0.9	0.4	0.267	0.12
Upper Franklin	700		9		78.0		9.2		2.0		2.05	
Lower Franklin	1,600		32		50.0		6.0		1.2		5.65	
Upper Hollywood	700		8		87.5		10.5		2.1		1.29	
Lower Hollywood	2,250	1,500	67	82	33.5	18.3	4.0	2.2	0.8	0.4	0.288	0.14
Silver Lake	3,700	2,000	85	85	43.5	23.5	5.2	2.8	1.0	0.6	0.71	0.4

The depth to which treatment should penetrate should be given much more consideration than it has received in the past. Growths of Anabaena and Aphanizomenon usually commence at the very surface of the water and can be eliminated by treating less than the top three feet of water. On the other hand, diatoms of troublesome types usually start at 20–30 feet depth. Some growths in new deep reservoirs occasionally may need to be reached at 100 feet or more depth. The old method except in a general way of feeding light or

heavy is totally useless in providing for such discrimination in treatment. When the corrected dosage rate has been determined, which normally varies from 0.16 to 1.06 p.p.m., and the required depth to which effective treatment is determined, which may vary from 3 to 100 feet, the total volume of water and the requisite total amount of copper sulphate can readily be obtained. This value can then be

TABLE 2

Copper sulphate dose corrections for temperature and alkalinity corrections

RESERVOIR	July and August temperature		Alkalinity as $CaCO_3$		Asterionella, basic dose, 0.1 p.p.m.		Fragilaria, basic dose, 0.25 p.p.m.		Melosira, basic dose, 0.30 p.p.m.		Aphanizomenon, basic dose, 0.15 p.p.m.	
	Top	Bottom	CO_3	HCO_3	For temperature	For temperature and alkalinity	For temperature	For temperature and alkalinity	For temperature	For temperature and alkalinity	For temperature	For temperature and alkalinity
	°F.	°F.										
Haiwee	70	60	28	107	0.115	0.19	0.29	0.49	0.35	0.58	0.17	0.28
Fairmont	72	70	0	122	0.118	0.19	0.30	0.48	0.35	0.56	0.18	0.29
Bouquet	70	55	0	148	0.115	0.20	0.29	0.51	0.35	0.61	0.17	0.30
Dry Canyon	72	67	10	133	0.118	0.20	0.30	0.51	0.35	0.60	0.18	0.31
Upper San Fernando	73	68	10	117	0.119	0.19	0.30	0.49	0.36	0.59	0.18	0.29
Lower San Fernando	77	70	10	135	0.126	0.22	0.32	0.55	0.38	0.66	0.19	0.33
Chatsworth	80	75	60	102	0.131	0.24	0.33	0.60	0.39	0.70	0.20	0.36
Encino	78	71	60	92	0.127	0.22	0.32	0.56	0.38	0.67	0.19	0.33
Stone	77	69	10	143	0.126	0.22	0.32	0.56	0.38	0.67	0.19	0.34
Upper Franklin	75	73	10	145	0.122	0.22	0.31	0.55	0.37	0.66	0.18	0.32
Lower Franklin	75	68	10	135	0.122	0.21	0.31	0.53	0.37	0.64	0.18	0.31
Upper Hollywood	70	68	10	135	0.115	0.20	0.29	0.50	0.35	0.60	0.17	0.29
Lower Hollywood	75	71	10	145	0.122	0.22	0.31	0.55	0.37	0.66	0.18	0.32
Silver Lake	80	77	35	100	0.132	0.22	0.33	0.55	0.39	0.65	0.20	0.33

reduced to the number of pounds of copper sulphate to each acre requiring treatment. This fixed amount varies from 1.34 to 900, and generally averages about 7 pounds per acre. It is evident that a fairly reliable method which can be adjusted to these variations is desirable.

Careful statistics have been kept for the past three years at Los Angeles in determining the minimum feeds which in actual practice

can be fed per acre by the old method. This information is based on a total use of 300 tons of copper sulphate applied at 14 different reservoirs. The procedure in varying and regulating doses is admitted to be crude even with all improvements of the process being used. If light doses are to be applied a single sack of double thickness is barely placed in the water, small pea sized crystals are used with a light and regulated feed, the copper sulphate is ladled, scooped or fed by hoppers into the sacks in small and regulated amounts, fast speed of the boats is employed and the lanes of travel are kept just as far apart as possible. Conversely, when heavy doses are to be used, two or more sacks are hung deeper into the water, more copper sulphate of medium sized crystals is placed in the sacks, the boats are operated at lower speeds, and the lanes of travel are made a minimum. Invariably, the smaller dosages fail because of the practical inability to evenly distribute small amounts of copper sulphate over the area to be treated. The addition of copper sulphate is aided by moderate wave action and is hindered by the increased drag on the boat with the varying weight of copper sulphate being dragged by the boat. The varying speed of the boat as its load becomes lessened introduces another error. All of these factors combined make it next to impossible to make anything other than a crude approximation.

Actual results show that the minimum dose which can be applied using all of the above precautions averages 27.2 pounds per acre and that under extremely favorable conditions an occasional figure of 15 pounds per acre can be reached. Regulation of doses from 25 to 45 pounds per acre can readily be secured, but for doses under 25 pounds per acre the procedure is too uncertain and unreliable to insure adequate and satisfactory results. Likewise it can be shown that heavy surface application to reach deep water treatments results in gross overtreatment of the top water with doubtful value so far as getting effective copper to the deep water.

The use of boat lanes at right angles to each other and spaced twice as far as the lanes would be in parallel lines of treatment has been recommended, but it results in gross overlapping and in extreme nonuniformity of application. In such a scheme with the lanes spaced 100 feet apart the overlapping colored zones of copper material amounts to 4 percent of the area covered and 50 percent of the area will have received duplicate treatment and over dosage varying from 1 to 99 percent.

It is only too self-evident that the old method is not susceptible to the degree of refined adjustment in feed that theoretically is required and accordingly gross wastage of chemical is inevitable. Since the average dose should be 7 pounds per acre, it is readily seen that the old method uses nearly four times as much copper sulphate as is necessary. This is a serious indictment because it means for the City of Los Angeles an estimated waste of over $5000 per year. Because of this one factor alone the author attempted to work out a better procedure.

The difficulties of the old method are both physical and chemical. The object in copper sulphate treatment is to add copper in a soluble active form for the destruction of microscopic organisms. The toxic action is supposedly most effective just as the copper sulphate goes into solution. In the laboratory copper sulphate when added to local natural waters almost instantly forms intermediate basic carbonates which can be seen as a diaphanous sheath hovering in the vicinity where it was formed. In all probability, the copper in this stage is not as active on algae as it is in its ionic form. After several hours the copper carbonates become entirely converted to copper hydroxide with the release of carbon dioxide. In this form the copper is positively inert and after forming a floc rapidly settles to the bottom.

TABLE 3

DEPTH	POUNDS PER ACRE TO GIVE 1.5 POUNDS PER MILLION GALLONS
feet	
5	2.5
15	7.5
30	15.0
45	22.5

In actual practice when copper sulphate is added by the old method there are numerous lanes covered by the boat in which there has been gross overtreatment at the surface with the hope that copper in its active form might cover the entire surface. It is noted that the copper sulphate going into solution immediately fans out into a cross-section area about 3 feet wide and 2 feet deep depending upon the motion of the boat. Depending upon the speed of the boat and distance between lanes of travel the concentration

with a feed of 25 pounds per acre varies from 50–100 p.p.m., which represents gross overtreatment. The solution of copper compounds settles faster than it diffuses laterally, in fact, in many instances it has but very little lateral diffusion except in moderate wind and wave action. Under favorable conditions the overtreated cross-section, within a few minutes time, widens out to 15–20 feet width but its depth has increased to 30–50 feet, giving a concentration of copper compounds of 0.1 to 10 p.p.m., which again represents overtreatment so far as depth is usually concerned and results in a very serious uncertainty of covering the entire surface with required concentration if the lanes of boat travel are more than 15–20 feet apart. The copper in this wider zone, as it can be seen lying listlessly in the water, is presumably in intermediate basic carbonate forms, and its usefulness after 15 minutes interval is questionable. When the copper compounds form a floc or are definitely in a hydroxide form, the copper rapidly settles out. There are occasions in which copper hydroxide floc settles out long before the copper could diffuse laterally more than 15 feet from the point of application. There are indications that under favorable conditions where carbon dioxide is present, copper remains in solution for several hours. It is granted that much research work is needed to substantiate some of these observations, but the fact remains that the present method is entirely too crude to expect successful displacement of copper in an active form when fed in economical dosage rates in lanes 20 to 100 feet apart. How much copper is wasted by becoming chemically inert so far as algicidal action is concerned has not been determined, but it is certain to be a substantial quantity.

The time consumed in treating reservoirs is an important factor, not only as regards expense, but in the ability to complete treatment before wind or darkness causes overlapping of treated areas with untreated zones. Small reservoirs can be treated at the rate of 1 hour for each 10 acres, whereas, large reservoirs average about 1 hour for each 30 acres. It is apparent that in one 8 hour day a reservoir of 240 acres means an all day period of treatment. In some reservoirs two or more days are often employed to complete a single treatment. During such an interval the wind not only may change in intensity but in direction. This is obviously a slow procedure and greatly militates against obtaining good and consistent results.

Labor in applying copper sulphate usually requires three man

hours for 10 to 30 acres covered, depending upon the size of the reservoir. The cost of labor by the old method for large reservoirs is about 10 percent of the chemical cost per acre. If, however, the theoretical amounts of copper sulphate could be applied by the old method the labor cost would amount to 30 percent of the chemical costs.

The old method with its various improvements can, therefore, be classed as crude, wasteful, incapable of applying required minimum doses, chemically inefficient, excessive in its time required to treat a reservoir, and involves a relatively high labor cost.

ACCOMPLISHMENTS WITH THE NEW METHOD

The writer in January, 1931, first thought of the possibility of applying copper salts to reservoirs in dry form from an aeroplane. Several commercial aviation companies were consulted, and it was concluded that the cost of distribution would be prohibitive because only 25 percent of the copper sulphate is copper. It was thought that copper chloride which can be manufactured in small crystalline and dry form which contains 52 percent copper and which is anhydrous might be easier to distribute economically by aeroplane. Chemical companies were unable, however, to produce copper cheap enough for such a procedure.

After various discussions it was decided in 1934 to experiment dusting with dry copper sulphate using equipment similar to spreading of copper sulphate for insecticide purposes. A small hand-operated machine furnished by the Los Angeles Chemical Company was tried out on Silver Lake Reservoir on November 23, 1934, and performance tests on the uniformity of surface and depth distribution were made in the field by the use of sodium sulphide reagent. So encouraging were these results that the Los Angeles Chemical Company developed a specially designed "broadcaster" consisting of a hopper holding 250 pounds of copper sulphate of dry crystals passing a screen with 16 meshes to the inch with a graduated orifice capable of adjusting the feed from 5 to 50 pounds per minute and which discharged into a beveled and baffled vertical disc driven 1400 RPM by a ½ H.P. 4 cycle gasoline motor.

This equipment was first tried out at Silver Lake Reservoir on January 10, 1935, and again at San Fernando Reservoir on January 12, 1935. To date over 80 tons have been added to seven of the largest reservoirs, and while certain improvements are yet to be made,

the results more than justify continuing the development of the new process.

The machine in calm water throws the heavier crystals over a width of 40 to 50 feet with the dust amounting to a small percentage of the weight settling near the boat. In high winds the material is carried into the water on one side of the boat for distances of 100

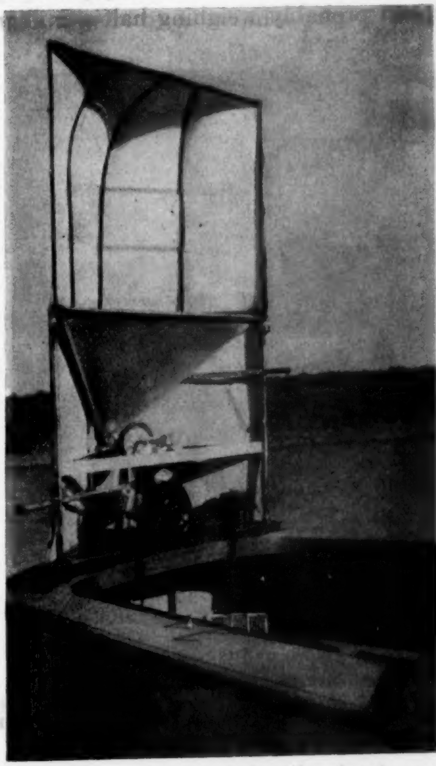

FIG. 1. COPPER SULPHATE SCATTERER SHOWING MOTOR AND HOPPER FROM BOAT SIDE

to 200 feet. The lanes of boat travel can be made twice as far apart as in the old method. In the new procedure there is no gross discoloration of the water in the wake of the boat. There is no visible zone of excessive overtreatment, which is a decided advantage. It is generally true that if the copper sulphate has been added so heavily that it discolors the water, too much has been used.

In the laboratory three different size crystals were experimented within a 5 foot length of 2-inch glass tubing. The largest size passing a screen with 16 meshes to the inch and weighing about 4 milligrams traveled 20 feet vertically before dissolving and gave concentrations varying from a trace at the surface to 0.6 p.p.m. in the first five feet. A smaller crystal weighing 3 milligrams traveled 15 feet vertically and gave concentrations of 0.4 p.p.m. for the first five feet. A fine crystal probably weighing half a milligram descended

FIG. 2. COPPER SULPHATE SCATTERER FEEDING 10 LB. PER MINUTE

4½ feet before completely dissolving and gave an average concentration of 2 p.p.m. Copper tests in this work and in subsequent field tests were made using sodium di-ethyl di-thiocarbamate method.

In the field a test was made showing that material passing a 16 mesh to the inch screen gave 70 percent distribution in the top 3 feet of water, 17 percent at the 15 feet depth, 7 percent at 30 feet and none below 60 feet. Coarser crystals weighing approximately 5 milligrams gave 50 percent distribution in the top water and 2 percent reached a depth of 105 feet. It is apparent that by selecting

the size of crystals to be used that water at any desired depth may be treated with copper in an active form. Further, that active copper can be uniformily and instantly spread over the entire surface.

Treatments secured by the new method vary from 7.5 to 29.4 pounds per acre with an average figure of 15.3 pounds per acre. It is not believed possible to secure less than 7.5 pounds per acre by the present equipment now in use and the figure of 15.3 pounds per acre is the average, which includes higher amounts than were

FIG. 3. COPPER SULPHATE SCATTERER. BOAT SIDE ILLUSTRATING MASKS AND GOGGLES

necessary because of being too conservative in reducing dosages all at once over what had been required by the old method. The present equipment can feed at a minimum rate of 10 pounds per acre, which compares with 27.2 pounds per acre by the old method. This means a saving at Los Angeles reservoirs of 63 percent in chemicals, which in the course of a year amounts to a saving of \$5000. It is generally conceded that reservoirs are not treated often enough because of the expense involved by the old method. By the new method reservoirs can be treated more frequently so that the

estimated annual saving can be put to the production of better water.

In the spreading of 80 tons of copper sulphate by the new method during the past 9 months the time required to apply copper sulphate has been at the rate of 1 hour for 28 acres in reservoirs less than 100 acres area and 1 hour for 140 acres for larger reservoirs. The saving in time is effected by the boat making faster time because of no sacks dragging in the water, no stopping to fill wet sacks with copper sulphate, ability to use wider distances between lanes of boat travel, less weight carried per trip and a less number of trips. The largest reservoir in the Los Angeles system can now be treated in less than 8 hours, which formerly required 20 hours. The average time of treatment of all reservoirs is 4 hours compared with 12 hours by the old method. This enables reservoirs to be treated in their entirety before wind or wave action can disrupt continuity of treatment.

Up to the present time the same number of men per hour have been used on the new procedure as in the old one, but instead of using 3 men there is no reason why 2 men cannot effectively handle the job, provided certain minor improvements can be made in assuring that the copper sulphate does not become lumpy while in storage. But even with 3 men on duty the new method reduces the labor costs 66 percent. There is hope that it will be cut 78 percent. This cost will then amount to but 5 percent of the new chemical cost and again warrants additional time being spent in treating reservoirs to improve the quality of the supply.

The new method obviates the use of burlap sacks which are costly, in that they can be used but for one treatment because of deterioration due to traces of free acid in the copper sulphate.

It is still desirable to develop equipment which can feed copper sulphate at a rate of 5 pounds per acre which is equivalent to 6 pounds per minute when a boat with a speed of 12 miles per hour is used. This can be obtained by projecting the "scatterer" backward 4 to 6 feet from the rear of the boat, by providing a low hopper mechanically feeding the "scatterer" and by removal of all overhanging or interfering obstacles which would throw the copper sulphate directly downward into the water. Some minor trouble has been noticed of the copper sulphate lumping while in storage and not flowing free when placed in the "scatterer." This causes some slight overtreatment in the wake of the boat unless the lumps are broken up. The lumps are not hard and a slight pressure breaks

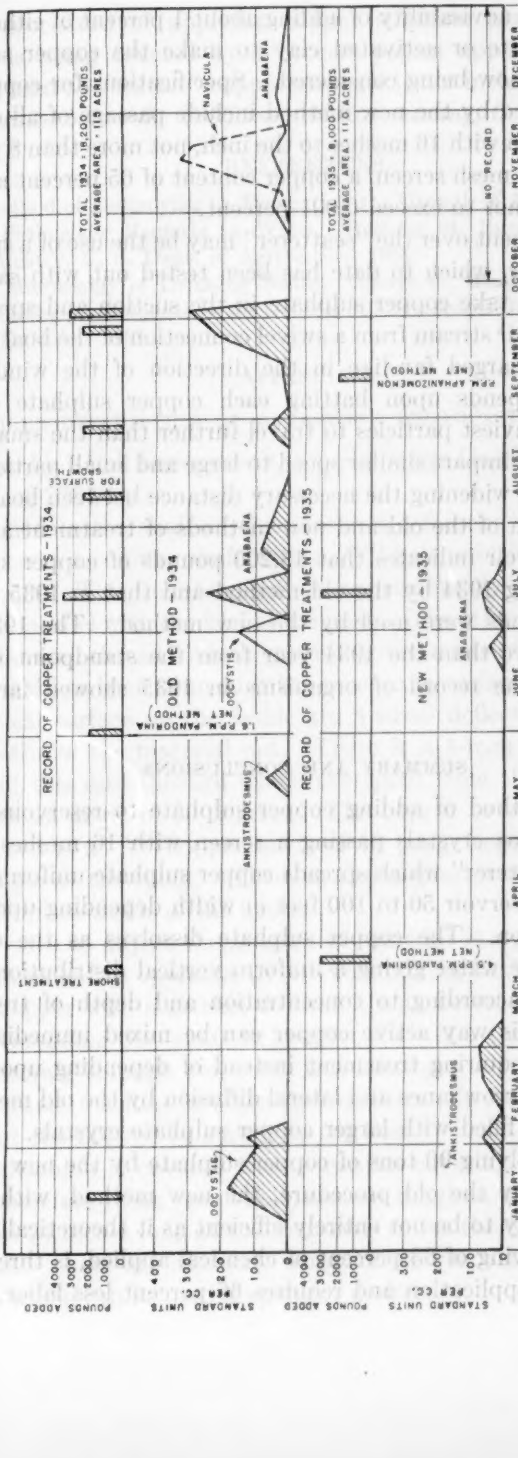

FIG. 4. COPPER SULPHATE TREATMENT AND MICROSCOPIC ANALYSIS—STONE CANYON RESERVOIR, LOS ANGELES. OCTOBER, 1935. DAILY RECORD SHEET

them up. The advisability of adding about 1 percent of either magnesium carbonate or activated clay to make the copper sulphate free flowing is now being considered. Specifications for copper sulphate to be used by the new method include passage of all crystals through a screen with 16 meshes to the inch, not more than 8 percent passing the 150 mesh screen, a copper content of 65 percent and free sulphuric acid not to exceed 0.001 percent.

An improvement over the "scatterer" may be the use of a specially designed blower, which to date has been tested out with sand dispersal. It will take copper sulphate in the suction and spread the material in an air stream from a swivel connection of the boat so that it can be discharged fan-like in the direction of the wind. The "scatterer" depends upon batting each copper sulphate crystal, causing the heaviest particles to travel further than the small ones. The blower will impart similar speed to large and small particles and may succeed in widening the necessary distance between boat lanes.

A comparison of the old and new methods of treatment at Stone Canyon Reservoir indicates that 18,200 pounds of copper sulphate was used during 1934 by the old method and that in 1935 to date only 8000 pounds were used by the new method. The 1935 year was more severe than the 1934 year from the standpoint of algal troubles, yet the record of organisms in 1935 showed far better control.

SUMMARY AND CONCLUSIONS

The new method of adding copper sulphate to reservoirs is the scattering of fine crystals passing a screen with 16 meshes to the inch by a "scatterer" which spreads copper sulphate uniformly over sections of a reservoir 50 to 100 feet in width depending upon wind and wave action. The copper sulphate dissolves as the crystals fall through the water giving a uniform vertical distribution which can be varied according to concentration and depth of treatment desired. In this way active copper can be mixed immediately in all the water requiring treatment instead of depending upon overtreatment of narrow lanes and lateral diffusion by the old method of dragging sacks filled with larger copper sulphate crystals.

Based in applying 90 tons of copper sulphate by the new method and 300 tons by the old procedure, the new method, with equipment admittedly to be not entirely efficient as it theoretically could be, effects a saving of 63 percent of chemical applied, is three times quicker in its application and requires 66 percent less labor.

The procedure of applying copper sulphate crystals over the surface is being covered by a process patent application, but the method used to "scatter" copper sulphate is not included.

(*Presented before the California Section meeting, October 25, 1935.*)

REFERENCES

(1) A Method of Destroying or Preventing the Growth of Algae and Certain Pathogenic Bacteria in Water. Bulletin 64, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1904.

(2) The Microscopy of Drinking Water. George C. Whipple. 1914.

(3) Use of Copper Sulphate in the Control of Microscopic Organisms. Frank E. Hale. 1935.

APPENDIX 1

DETAILED DESCRIPTION OF BLUESTONE BROADCASTING MACHINE

Driven by a half horse power, 4 cycle Briggs Gasoline Motor with a speed of 2200 r.p.m.

Attached to the shaft of this motor is a 6-inch "V" type pulley which drives a counter shaft with a "V" belt reducing the speed to 1100 r.p.m. This counter shaft is approximately 26 inches long, running parallel with the keel of the boat. The other end is attached with a beveled thread 12-inch spreading disc made of 16 guage sheet copper and has been spun so it has a concave surface. Attached on the conical surface on the inside are 8 small deflector strips which help to throw the material out. There is a 4-inch opening in the center of this disc through which the spout from the hopper is inserted at an angle of 60 degrees. The hopper to which this spout is attached is a "V" hopper made of 16 guage copper and has the same angle as the spout. There is also a quarter mesh detachable screen to place inside of the hopper.

The valve to adjust the amount of material is a gate that works in a groove and is operated by a lever running back along the side of the hopper with a ratchet so that it may be set at any position.

The spreading disc shaft or counter shaft is a three-quarter inch shaft running through two s.k.f. ball bearings.

The whole machine is supported on an angle iron frame with a clamp at the bottom to attach to the boat.

The machine is covered with a canvas covering which snaps in place, therefore being removable, and an isinglass window 10 inches high and 24 inches long at the rear so as to see the operations of the machine. There are also side wings of canvas, made of pipe and canvas, which can be used if operator desires.

PRACTICAL PROBLEMS IN WATER DISTRIBUTION

By E. W. Breitkreutz

(*Assistant Engineer, Bureau of Water Works and Supply, Los Angeles, Calif.*)

This subject is of such broad scope that the time allotted will, of necessity, limit the field that can be covered, and the writer will confine himself only to experiences in the Los Angeles Water Bureau during the past twenty-two years.

As an example of a problem in the days when such a thing as a sanitary engineering division was unknown in the Water Bureau, a leak crew was called upon to determine the origin of a certain leak on Wilshire Boulevard. There was some question as to its source, it possibly being from a broken sewer. The foreman in charge of the crew did not waste much time debating the question; he scooped up a handful of water, tasted it, and remarked, "It's not from a sewer."

However, the men in charge of the construction, maintenance, and operation of the Los Angeles water distribution system of 3828 miles of pipe and appurtenant valves, fire hydrants, etc., are a serious minded group. The mention of personnel brings to the fore a problem caused by the lay-off of employees during the present depression. The lay-off was according to seniority. The younger men were let out first, leaving very few come-along men to take the places which will, from time to time, be made vacant by the loss of older men. Seniority must be followed in laying off civil service men, but it certainly is advisable to follow the rule of the "survival of the fittest" in the case of unclassified labor.

VALVES

Valves—shut-off, regulating, altitude, relief, check, and float valves—are a very vital part of the distribution system. In the Los Angeles distribution system, exclusive of San Fernando Valley, about 40,000 shut-off valves, or "gates," as they are shown, are in operation. These are of approximately thirty different makes. Stocking of repair parts for such a group of gates is a problem in itself.

About five hundred stems, consisting usually of one sample and two spares, must be kept on hand in an emergency tool room accessible at all hours to the proper employees.

Shut-off valves are usually kept in the open position in the distribution system. Bronze mounted double disc iron valves in corrosive waters build up between the discs in the open position, sometimes making the valve inoperative. Under ordinary domestic pressure, brass trimmed, solid wedge valves operate satisfactorily for

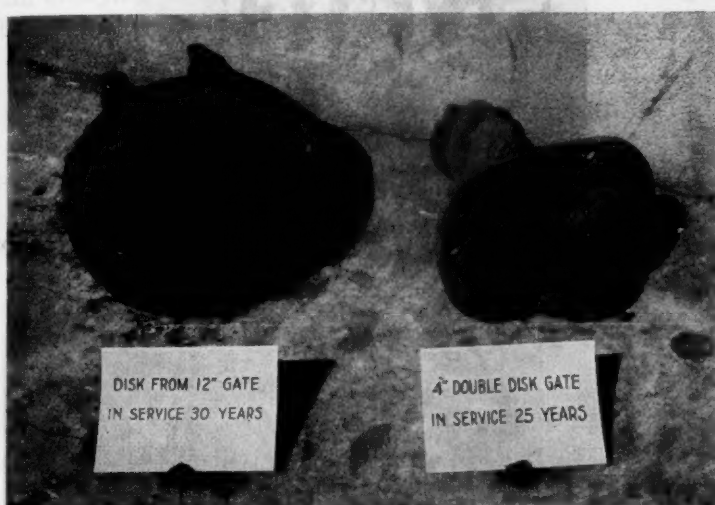

FIG. 1. BADLY CORRODED IRON GATE DISCS

Corrosion products cement wedges and other parts together, and expand discs.

all sizes below 12-inch. All larger valves should have solid bronze discs with other moving parts made of the same material.

There are occasions when it is desirable to cut down the flow in certain mains; this has been done by partly closing a gate in the line. Gate discs projecting into the stream set up vibrations that are sometimes annoying to consumers and if left in the stream long enough, these vibrations may cause wear sufficient to allow the discs to drop off from the stem and do considerable damage by water hammer or by decreasing water available for fire protection. The solution is to arrange a battery of valves in various sizes so that complete closures of one or more would give the desired results.

FIG. 2. IRON GATE DISCS IN SERVICE 13 YEARS IN HORIZONTAL VALVE. BADLY CORRODED AND PACKED WITH FINE SAND

FIG. 3. TESTS OF 12-INCH GATE VALVES UNDER PRESSURE OF 175 POUNDS PER SQUARE INCH

Such tests are made where such pressure is available in 12-inch main and there is no traffic on the concrete streets.

Valves when used as dividing gates between districts of different elevation result in objectionable dead ends. These gates are frequently "cracked" to permit enough circulation to overcome this

objection, but the consequent high velocity will cut the discs and seats so that a tight shut-off cannot be made when occasion demands. Where the pressure on the high side of the dividing gate is from gravity supplied water, a good procedure is to by-pass the gate with a ½-inch copper service connection, placing the stop-cock in a 6-inch gate well. If the high pressure side of the dividing gate is from pumped water, then the by-pass flow should be controlled by an orifice in a blind union, amply protected by a strainer.

An annoying problem is the leaking of gates at the stuffing box after they have been operated for a shut-off. Gate-stem packing

FIG. 4. BACK VIEW OF SAME 12-INCH GATE TESTS SHOWING MANIFOLD TO WHICH SEVERAL GATES ARE ATTACHED

Water is taken through 6-inch fire hydrant riser

dries out and shrinks with age, and old tallow destroys the flax. A good flax oil-impregnated packing that remains resilient will overcome this difficulty. Leaky packing can be replaced without tearing up pavement and removing the gate well if the stuffing box bolts are within hand reach from the street surface. This repacking requires the use of a puller for removing the gate key nut from the stem, and operations are greatly facilitated if the stuffing box bolts and nuts are of bronze and the operator has nimble fingers.

Keeping valves in good working order at all times is a problem requiring eternal vigilance. How often should valves be inspected and operated? In the case of trunk lines, all valves—main-line,

lateral, and blow-off,—should be operated at least once every six months and inspected every ninety days. Other valves in the gridiron system should be operated annually and inspected semi-annually. During the regular semi-annual operation, trunk line valves are closed to a point where they begin to whistle and all others are completely closed except dividing and blow-off gates which are operated only a few turns. During the operation rounds, stand pipes, gate-caps, manholes and covers, gears, leaky stuffing boxes, etcetera, get a thorough going over. On the inspection rounds, trunk line valves are closed about one-third and others are given a few turns. In addition to the regular inspection and operation, all valves are inspected whenever streets are resurfaced or improved by contract. In preparing for shut-offs for connections, etcetera, valves should be gone over several days in advance.

Altitude valves controlling the water level of tanks or reservoirs will sometimes give trouble in case of sudden peak demand when the valve is closed at the high water position. The sudden demand may create a vacuum on the low side and the valve fail to open. This may be avoided by by-passing the altitude valve with a check valve.

Pressure regulating valves are installed singly, in pairs, and arranged in graduated sizes. A large single regulator out of order can cause a lot of trouble and the chances of more than one of a pair or more going out of order at the same time is remote. Of course, there should be a through connection with valve on the main line to facilitate repairs. Needle and pilot valves clog up if not properly protected by strainers. If the differential pressure is high, noises and vibrations may be avoided by reconstructing the piston with a perforated or saw-tooth skirt. Right angle connections, when there are high velocities, are the cause of some of the noises of vibrations. These noises and vibrations may be reduced by blocking the vibrating sections to the reinforced roof of the vault. Residual stresses due to welded and flanged connections can be eliminated by the use of at least one lead joint in each branch of a regulator layout.

Every system supplied through regulators should at all times be adequately connected to a reservoir controlled by an overflow, or if the system is closed, a relief valve of proper size must be installed. A well lighted regulator pit equipped with an automatic sump pump greatly facilitates repairs and inspection.

The secret of the success of regulating and altitude valves is con-

stant watchfulness, and one of the best helps toward this end is the seven day pressure recording gauge. These gauges, with dual pens, installed at each important valve, make weekly inspections mandatory, because the recording charts must be changed and the clocks must be wound regularly. The charts tell the whole story of what takes place on either side of regulating or altitude valves, inoperative relief valves, water hammer, excessive demands, main failures, etc. Also, they show low consumption from tanks, indicating when manual operation is necessary to keep the contents fresh. Of course, the ideal condition would be to have the Superintendent's office equipped with remote controlled recording gauges connected to the various important points in the distribution system.

FIG. 5. TWENTY-FOUR-INCH HORIZONTAL GATE VALVE SET UP AT SAME PLACE FOR FULL PRESSURE TEST
Notice position of hand on 200-pound pressure gauge

INTERFERENCE OF OTHER SUBSTRUCTURES

One of the most perplexing problems that confronts the water works superintendent is the interference of utility and public works substructures. It would seem that water, without which the existence of the human race would be a matter of hours, should have some preference as to substructure location in the public streets. However, such is not the case in Los Angeles where water mains sometimes take what is left—a location that would make a gopher dizzy to follow. All substructures constructed under the jurisdiction of the city, county, or state take preference over existing water mains,

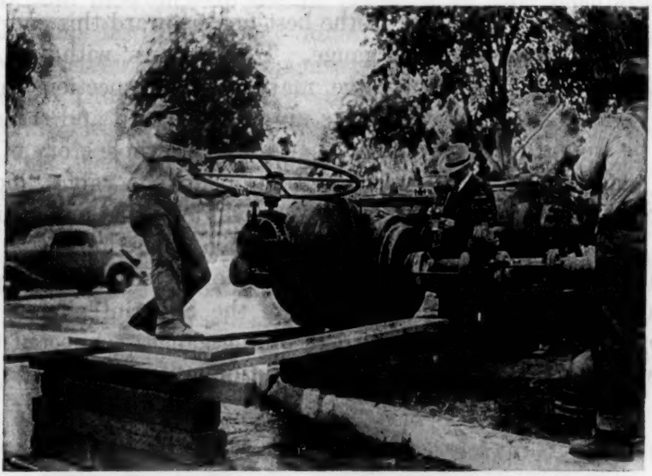

FIG. 6. THE OTHER 24-INCH VALVE

Notice 24-inch joint to reducer is not held by rods. This joint is cement, and is holding 103,000 pounds.

FIG. 7. W. W. HURLBUT AND THOMAS BROOKS OBSERVE TESTS

Mr. Van Norman was also present but did not get in the picture. In the foregound is L. A. Ghiotto, Superintendent of Pipe Construction.

which must be relocated at the Department's expense. Private utilities are given permits to install structures in the streets without apparently any consideration as to possible damage to existing water lines or interference with location of future lines. Consequently,

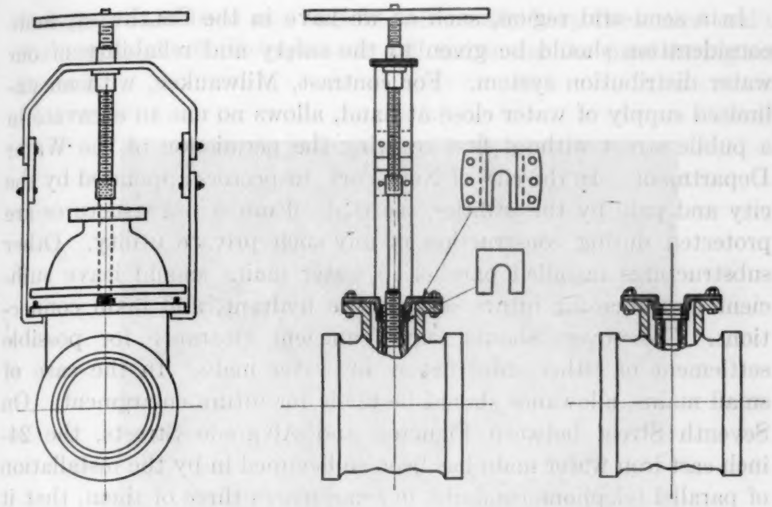

FIG. 8. DEVICE FOR HOLDING DISC IN VALVE WHILE REMOVING BONNET AND REPLACING BROKEN STEM WITH FULL PRESSURE IN MAIN

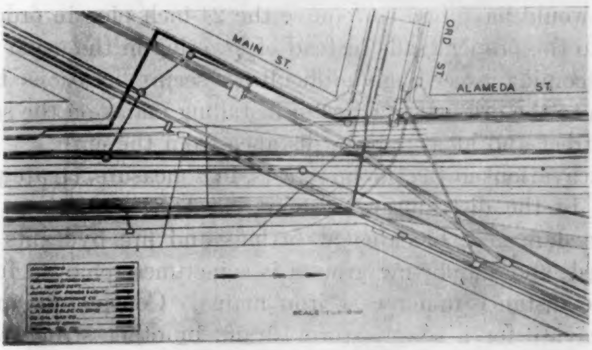

FIG. 9. A COMPLICATED WEB OF SUBSTRUCTURES AT ORD AND ALAMEDA STREETS

This type of intersection is usually associated with the congested business district. The 36-inch water main installed 1903 before every other structure except sanitary sewer and the west street car track, must now be moved for box section storm drain.

concrete structures have been built in direct contact with, and sometimes encasing, cast iron mains. Every such contact is a potential break.

In a semi-arid region, such as we have in the Southwest, more consideration should be given to the safety and reliability of our water distribution system. For contrast, Milwaukee, with an unlimited supply of water close at hand, allows no one to excavate in a public street without first securing the permission of the Water Department. In the city of New York, inspectors appointed by the city and paid by the utilities, see that all municipal structures are protected during construction of any such private utility. Other substructures installed parallel to water mains should leave sufficient clearance for future service, fire hydrant, and main connections. Cross-overs should leave sufficient clearance for possible settlement of either substructure or water main. In the case of small mains, allowance should be made for future enlargment. On Seventh Street between Figueroa and Alvarado Streets, the 24-inch cast iron water main has been so hemmed in by the installation of parallel telephone conduits, in some places three of them, that it is quite a problem to tap the water main. Some years ago the City proposed changing the grade of a portion of this street. If this proposal had been carried out, with no other space available, the Water Bureau would have had to remove the 24-inch pipe in order to excavate to the proper grade instead of lowering in the usual manner. It is becoming exceedingly difficult to secure locations that will conform to the original practice of installing mains on the same side of the street and at a uniform distance from the curb.

All excavations in the public streets, in a measure, create potential hazards to the distribution system. Protective coatings on steel pipe are damaged; blocking at fittings and fire hydrants may be weakened; and supporting ground is sometimes removed for a considerable distance under cast iron mains. Contractors sometimes will excavate for a sewer, storm drain, or other structure closely parallel to and below water mains without notifying the Water Bureau. The fact that these things are permitted requires constant vigilance on the part of water works employees.

Bridges and grade separation structures are each an individual problem. Generally, there are fills to cross from solid ground to a rigid structure. Usually the fills are made near the completion of a job and with the public clamoring to open the street to traffic, they are improperly made with a consequent settling. Lead joints will leak and may increase the settlement, especially if it is a dry fill. Steel pipe with a rubber packed coupling seems to be the most satis-

factory. Sand used as a backfill will usually keep the entire load of the pavement off the pipe as it will run under the pipe during settlement.

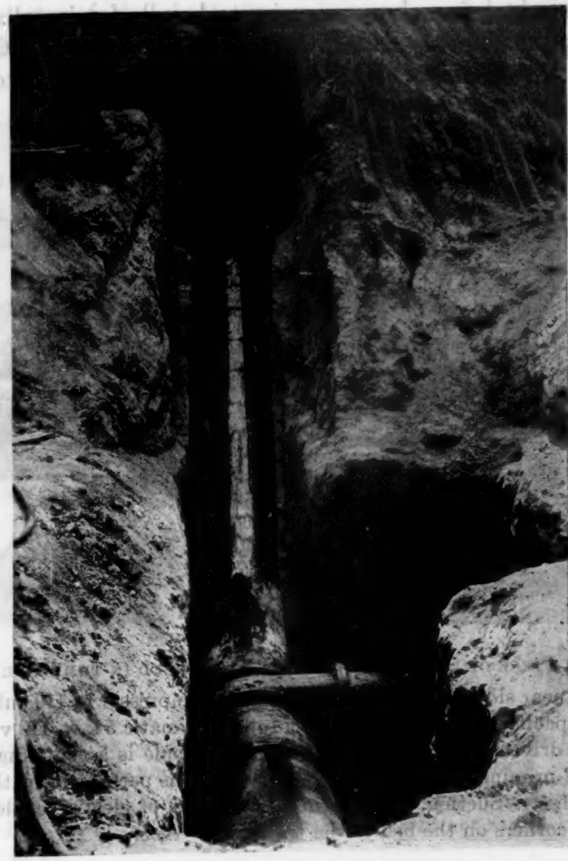

FIG. 10. A 30-INCH TRUNK LINE RUNNING UP A BANK AND INTO A TUNNEL RECENTLY INSTALLED FOR THE THIRD TIME BECAUSE OF STREET IMPROVEMENT

This last job was designed three times because of changes in the excavation lines by the City Engineer.

CAST IRON FITTINGS

In 1919 the writer spent the greater part of a year in working on the design of a uniform standard of cast iron fittings for the Water

Bureau. These fittings are known as the Los Angeles or short pattern, and they compare favorably with A.W.W.A. long pattern as to friction losses at ordinary distribution velocities. The short pattern fitting has several advantages over the long pattern, the lighter weight being cheaper, easier to handle for installation, and requiring smaller excavation. They are designed for Class "C" pressure with Class "C" bells, and spigots dimensioned to fit Class

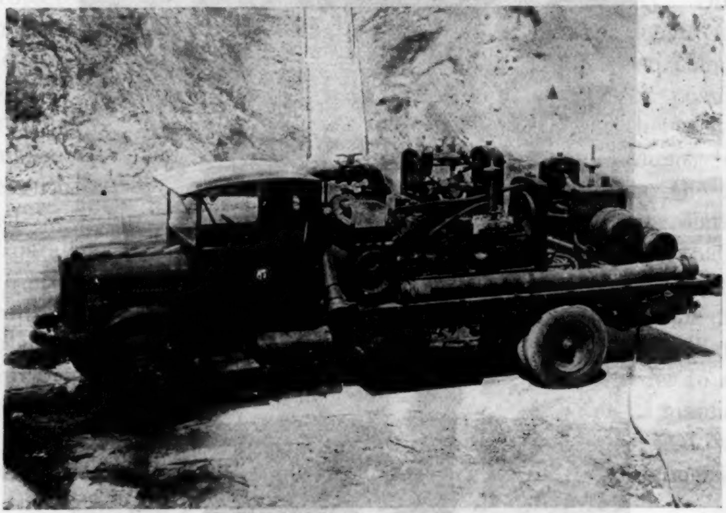

FIG. 11. A PIECE OF SPECIAL EQUIPMENT ASSEMBLED IN THE BUREAU'S SHOPS

On the near side is a gas engine driven air compressor of 110 cubic feet per minute capacity. Across the rear is a fully automatic 5 k.w. 110 volt electric generator driven by a gas engine. On the far side is a centrifugal pump—8-inch self-priming—with capacity of 1,200 gallons per minute with a suction lift of 25 feet. Suction hose, air hose, and reels of electric cable for lights fill in the corners on the bed of the track.

"B" pipe. There are two types of fittings that are quite handy. One is an offset in various sizes that is very convenient in ducking over or under interfering substructures. The other fitting is a double-bell sleeve used in making final connections. It slips over the cast iron pipe, keeps the two ends in line, and still has a shoulder to retain the yarn.

FIRE HYDRANTS

Fire hydrants used to be a source of considerable trouble for maintenance men. Valves worked loose because of operation and caused

chattering, and the rubber in the valves would sometimes form a lip that caused severe water hammer when the hydrant was operated. The use of a canvas inserted rubber has alleviated the latter trouble and a hydrant designed and patented by a Water Bureau mechanic has taken care of the chattering valve and made possible quick field repairs to stems, seats, and valves. The greatest trouble with

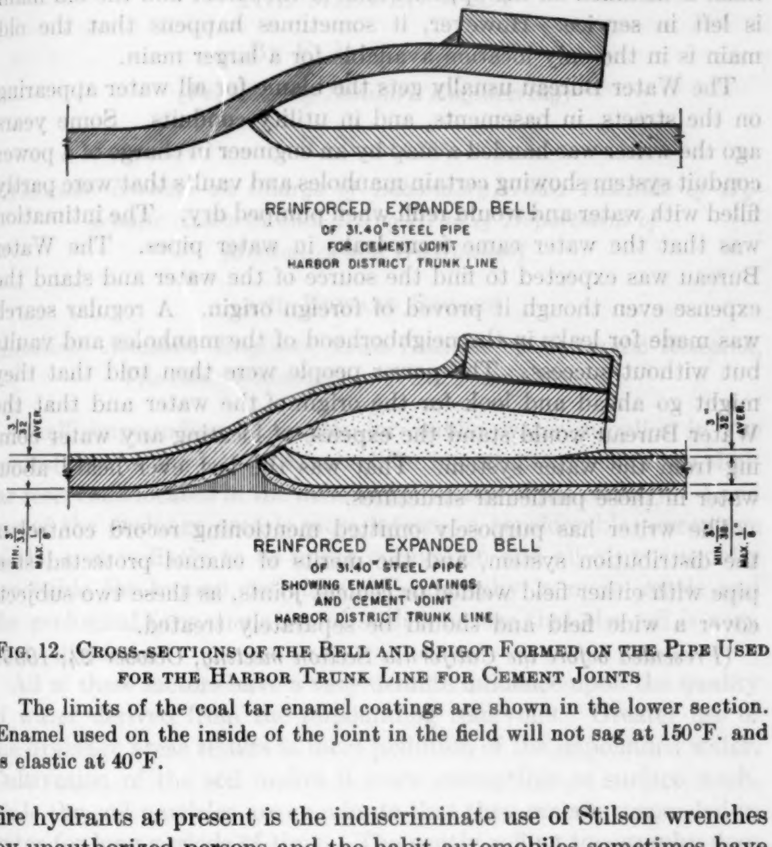

FIG. 12. CROSS-SECTIONS OF THE BELL AND SPIGOT FORMED ON THE PIPE USED FOR THE HARBOR TRUNK LINE FOR CEMENT JOINTS

The limits of the coal tar enamel coatings are shown in the lower section. Enamel used on the inside of the joint in the field will not sag at 150°F. and is elastic at 40°F.

fire hydrants at present is the indiscriminate use of Stilson wrenches by unauthorized persons and the habit automobiles sometimes have of leaving the traveled road and seeking out innocent fire plugs.

DOUBLE MAINS

Double mains avoid a good deal of pavement cutting for services installed after a street has been paved, cut down the number of consumers out of water during a shut-off, and increase fire protec-

tion. The number of valves required to properly gate a double main system is usually more than twice that of single mains and the system is considerably more complicated to operate. It can readily be seen that there can be quite a variation in arrangement of connections and valves at street intersections. Usually, when a main is inadequate for service in a business or industrial district, a larger main is installed on the opposite side of the street and the old main is left in service. However, it sometimes happens that the old main is in the only location available for a larger main.

The Water Bureau usually gets the blame for all water appearing on the streets, in basements, and in utility conduits. Some years ago the writer was handed a map by an engineer in charge of a power conduit system showing certain manholes and vaults that were partly filled with water and would refill when pumped dry. The intimation was that the water came from leaks in water pipes. The Water Bureau was expected to find the source of the water and stand the expense even though it proved of foreign origin. A regular search was made for leaks in the neighborhood of the manholes and vaults but without success. The power people were then told that they might go ahead and look for the origin of the water and that the Water Bureau would stand the expense of locating any water coming from the water system. That was the last ever heard about water in those particular structures.

The writer has purposely omitted mentioning record control of the distribution system, and the merits of enamel protected steel pipe with either field welded or cement joints, as these two subjects cover a wide field and should be separately treated.

(Presented before the California Section meeting, October 24, 1935.)

FUNDAMENTAL HYDROLOGIC CONSIDERATIONS FOR THE DESIGN OF IMPOUNDING RESERVOIRS IN THE MIDDLE WEST

By E. L. Waterman

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Small impounding reservoirs for public water supplies in the central area of the United States differ in certain respects from similar reservoirs located in the more rugged parts of the country. Land use of the drainage area is more intense, a considerable percentage of the area is likely to be under cultivation and all of it is usually accessible for human activities. Topography is more gentle and the geological formations are of such a nature that the soil is very finely divided.

All of these factors have a very definite influence upon the quality of water derived from the impounding reservoirs. Greater use of the drainage areas results in more pollution of the impounded water. Cultivation of the soil makes it more susceptible to surface wash, while the soil particles are so minute that they remain suspended in water for long periods of time. The gently rolling topography does not offer ideal reservoir sites. For these reasons purification of impounded waters is necessary to make them safe and palatable. Filtration and chlorination are the processes most commonly used.

Hence, for the conditions which we are considering, the primary factor in the design of an impounding reservoir is an evaluation of the hydrologic factors involved. The quality of water should have

consideration but only from the standpoint of the type of treatment which will be needed.

In a paper presented before the Missouri Valley Section meeting last year, Mr. A. H. Wieters brought together significant data on impounded water supplies in Iowa. Figure 1 shows the location of fourteen cities and towns (ranging in population from less than 1,000 to more than 8,000 persons) which depend wholly or in part upon impounded surface water for municipal supply. Of these impounded surface supplies, the five which did not fail are located at Albia, Chariton, Corydon, Centerville, and Lamoni. The reservoir at

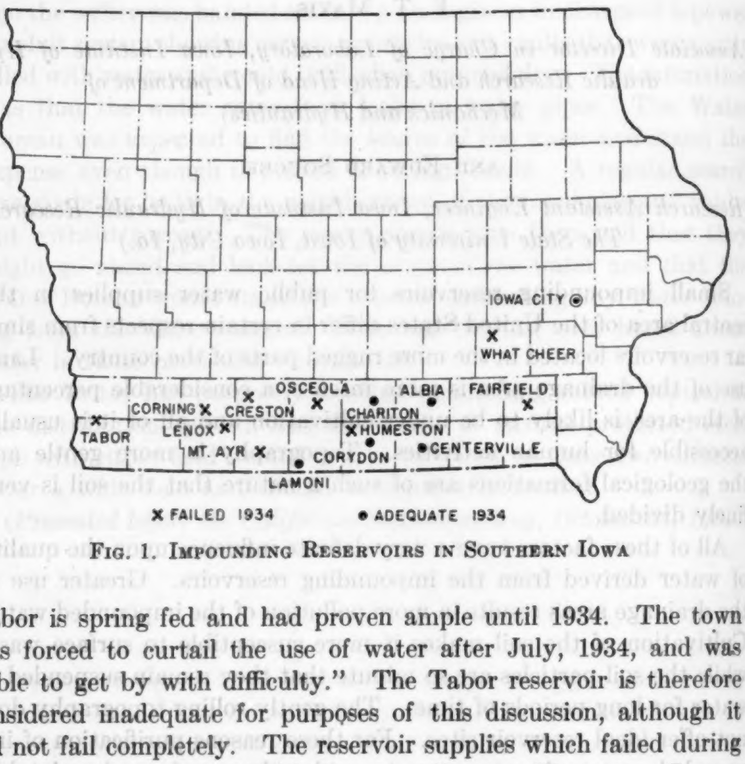

FIG. 1. IMPOUNDING RESERVOIRS IN SOUTHERN IOWA

Tabor is spring fed and had proven ample until 1934. The town was forced to curtail the use of water after July, 1934, and was "able to get by with difficulty." The Tabor reservoir is therefore considered inadequate for purposes of this discussion, although it did not fail completely. The reservoir supplies which failed during 1934 are located at Fairfield, Corning, Creston, Humeston, Lenox, What Cheer, Osceola, and Mount Ayr.

The watershed areas supplying the impounding reservoirs under discussion range from a minimum of 90 acres at Lenox to a maximum of 12,000 acres at Creston.

Table 1, adapted from Mr. Wieters' paper, shows a summary of the physical data pertinent to the analysis of storage requirements for impounding reservoirs on small watersheds in the middle west.

TABLE 1

*Summary of data on impounded water supplies in Iowa**

CITY	POPULATION, 1930	MEAN ANNUAL PUMPAGE, G.C.D.	DRAINAGE AREA, ACRES	RESERVOIR AREA, PERCENT	RESERVOIR CAPACITY FULL: M.g.	RESERVOIR CAPACITY FULL: Mg. per sq. mi.	MEAN ANNUAL DRAFT, M.G.D. PER SQ. MI.: Pumpage	MEAN ANNUAL DRAFT, M.G.D. PER SQ. MI.: Losses†	MEAN ANNUAL DRAFT, M.G.D. PER SQ. MI.: Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Albia	4,425	65	805	6	370	293	0.23	0.03	0.26
Centerville	8,147	62	1,700	6	400	151	0.19	0.03	0.22
Corydon	1,768	43	1,920	2	70	23.3	0.026	0.01	0.036
Fairfield (f)	6,619	56	768	8	180	150	0.31	0.04	0.35
Lamoni	1,739	24	400	8	30	48.4	0.066	0.04	0.106
Corning (f)	2,026	50	600	2	65	69.2	0.107	0.01	0.117
Creston (f)	8,615	99	12,000	1.5	296	15.8	0.045	0.008	0.053
Humeston (f)	924	65	650	4	45	44.1	0.059	0.02	0.079
Lenox (f)	1,717	27	90	8	18	129	0.34	0.04	0.38
Chariton	5,365	70	1,840‡	4	300	104	0.13	0.02	0.15
	Mean	55±17							
What Cheer (f)	1,310	55§	900	0.3	4	2.8	0.043	0.002	0.045
Osceola (f)	2,871	20¶	280	5	10	22.7	0.13	0.03	0.16
Mt. Ayr (f)	1,704	55§	640		23	23.0	0.093	0.005	0.098
Tabor (f)	1,048	55§	770		4.5	3.7	0.048	0.002	0.050

(f) Indicates that impounded supply was inadequate in 1934.

* Based on A. H. Wieters, "The Effect of Drouth on Public Water Supplies in Iowa," *Journal* Amer. W. W. Assn. 27: 154–163, Feb. 1934.

† Estimated at approximately 1 foot depth annually over reservoir area at spillway level (5,000 gallons per day per square mile drainage area for each one percent reservoir area).

‡ Prior to 1934.

§ Estimated on basis of average of other cities listed above.

¶ Estimated for fire and flushing only.

SCOPE

The object of this paper may be stated as follows:

1. To discuss briefly some of the hydrologic factors which should

be considered in designing impounding reservoirs on small drainage areas of one to ten square miles in Iowa and the central area of the United States.

2. To present an analysis of stream flow records collected on Ralston Creek near Iowa City over the period, 1925 to 1934, inclusive, in terms of storage requirements for various demands.

3. To compare the analysis of Ralston Creek data with similar data for eastern streams and with the experience recorded by Mr. Wieters for Iowa impounding reservoirs.

4. To present, tentatively, recommendations for the design of small impounding reservoirs in the central area.

FACTORS AND GENERAL CONSIDERATIONS

The storage required to enable a stream to supply a given draft over a more or less extended period of low stream flow depends (1) upon the average draft for the period, including losses, (2) upon the average yield of the stream over a long term of years, and (3) upon the minimum average yield of the stream over consecutive periods of low flow.

Assuming the geology of the reservoir and dam site and the construction of the dam itself to be such that seepage losses are small, the principal losses of water from the reservoir are due to evaporation. Let us assume that the total annual evaporation from shallow water is approximately 36 inches in Iowa. An analysis of annual rainfall records has shown that about nine years out of ten the annual rainfall at a station in the western section of Iowa has exceeded 20 inches and the annual rainfall at a station in eastern Iowa has exceeded 25 inches. Hence the net loss due to evaporation from a reservoir will be from 11 to 16 inches of depth over the mean water area during the period. Since great refinement appears to be unwarranted, we have assumed for the purpose of this study that the annual evaporation loss from the reservoir is approximately one foot of depth over the reservoir area at the spillway level. This is roughly equivalent to a daily loss of 5,000 gallons per square mile of watershed for each one percent of water surface on the drainage area. An allowance for evaporation losses, computed on this basis and converted to a mean daily draft, has been added to the mean daily pumpage in order to determine the total draft from the reservoir.

Certain other allowances should be made in the design of water

supply impounding reservoirs in the light of good sanitary engineering practice. For example, in calculating the available storage for an impounding reservoir in the Middle West, the volume of water in the reservoir when its maximum depth becomes less than about four feet should not be considered as effective storage. When the maximum depth of water in the reservoir is reduced to less than about four feet, the water is likely to have become rather unsatisfactory for domestic supply even after treatment, although it may still be valuable as an emergency reserve. Furthermore, this arbitrary allowance of the capacity below the four foot stage is a reserve for inevitable silt deposits.

In selecting the reservoir site and in designing the reservoir itself it should not be overlooked that flats alternately exposed and submerged may be particularly objectionable if vegetation has an opportunity to grow along the marginal fringes of the reservoir.

The foregoing general considerations pertain only to allowances for evaporation losses, to low water and silting reserves, and to the undesirability of shallow flats near the margin of the reservoir.

ANALYSIS OF RALSTON CREEK RECORDS

The Ralston Creek watershed is an agricultural area of three square miles extending eastward from the city limits of Iowa City. The topography of the area may be characterized as strongly rolling too rough with a maximum difference in elevation of approximately 160 feet. The surface soil is almost wholly Clinton silt loam and approximately one-fourth of the watershed is under cultivation.

Since September, 1924, continuous rainfall and runoff observations have been made on the Ralston Creek watershed and for some time ground water level observations have been made on seventeen wells at intervals of ten days or two weeks. The records of rainfall and runoff for the ten-year period 1925 to 1934, inclusive, are the basis for the following analysis of storage requirements for impounding reservoirs on small drainage areas in the Middle West.

Summary of rainfall and runoff records

Figure 2 shows the summary of annual precipitation and annual runoff, first, in chronological order, and second, in ascending order of magnitude of annual runoff. It is interesting to note from the latter plotting that the annual precipitation is arranged substantially in order of magnitude with two striking exceptional years, 1933 and

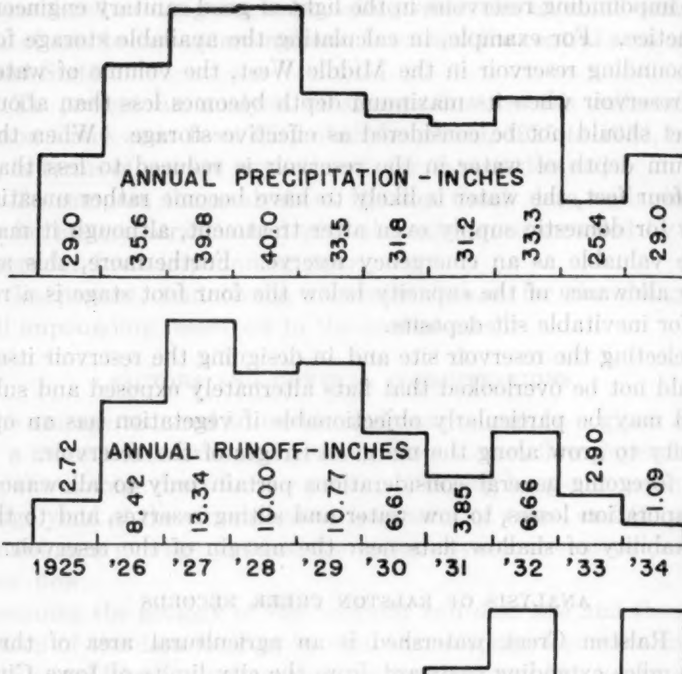

FIG. 2. ANNUAL PRECIPITATION AND RUNOFF, 1925–1934; RALSTON CREEK WATERSHED

1929. In these two years the annual runoff is appreciably larger than would be indicated by direct proportion to the annual precipitation. In each case it will be noted by referring to the chronological precipitation record, that the years of proportionately higher runoff, 1929 and 1933, followed years in which the precipitation was, respectively, 6.5 and 7.9 inches greater.

Figure 3 shows a relation between the mean annual rainfall and the corresponding runoff for consecutive periods of one to five years. It is not unreasonable that as the length of period increases, the re-

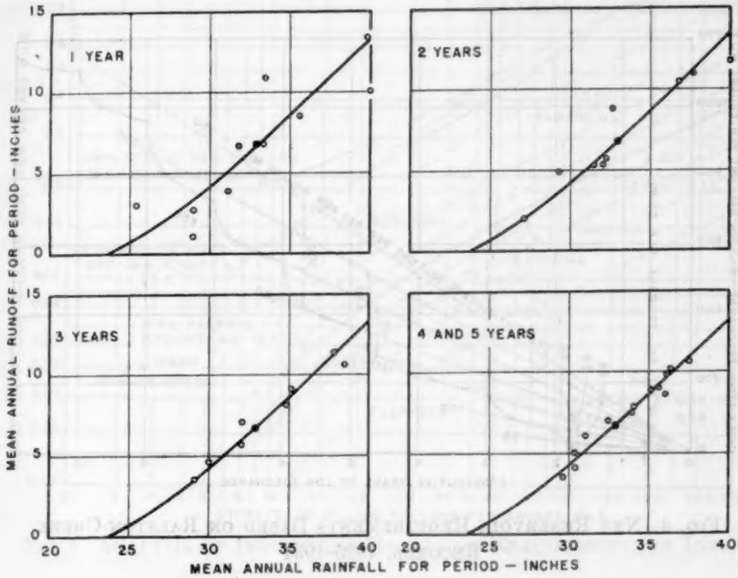

FIG. 3. MEAN ANNUAL RAINFALL AND RUNOFF FOR CONSECUTIVE PERIODS OF 1 TO 5 YEARS, RALSTON CREEK RECORDS, 1925–1934

lation between the rainfall and the runoff for the corresponding period should be better defined. The average discrepancy between mean annual runoff observed during a given period, and the corresponding runoff indicated by the curves shown in figure 3, is 1.5 inches for one year, 0.7 inch for two years, 0.5 inch for three years, and 0.4 inch for four and five years. Although simple relations between rainfall and runoff for a given watershed may be of little value in determining yield which may be expected in any one year, figure 3 seems to warrant the tentative conclusion that these relation-

ships may be helpful in estimating the yields which may be expected over periods of three or more years—periods which must be used as a basis for estimating reservoir capacity needs.

Relations between draft and storage for Ralston Creek records

Figure 4 shows the graphical method used for determining the net reservoir requirements based on the Ralston Creek records for the period, 1925 to 1934. The abscissas show the number of consecutive years of low discharge which correspond to each point plotted on the figure. The ordinates of each point represent the

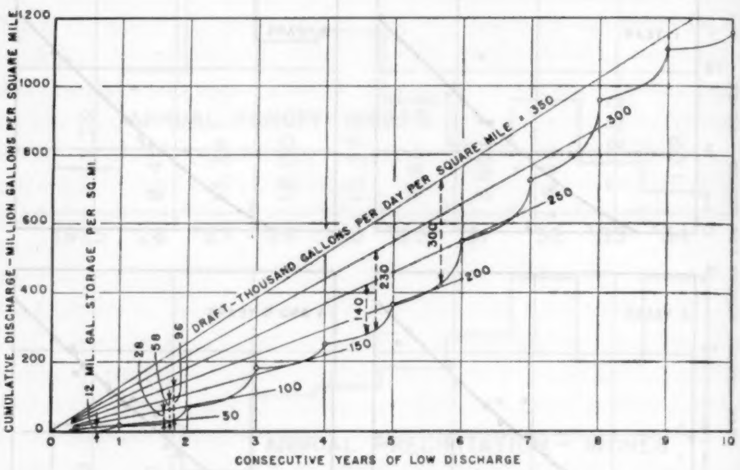

FIG. 4. NET RESERVOIR REQUIREMENTS BASED ON RALSTON CREEK RECORDS, 1925–1934

least cumulative discharge in million gallons per square mile for the corresponding number of consecutive years shown as abscissas. The curved line connecting each adjacent pair of plotted points was drawn on the basis of an analysis of duration curves showing the fluctuations of stream flow during an average year. In this manner reasonable allowances have been made for seasonal storage requirements on a simple rational basis.

The lines radiating from the origin are lines of mean draft in thousand gallons per day per square mile. The maximum ordinates between the curve and the draft lines represent, respectively, the amount of storage required to maintain the corresponding average

draft on the basis of the Ralston Creek records. Assuming the reservoir to be full at the beginning of the dry period which happens to be critical for a particular draft, the abscissa of the intersection of the draft line and the curve indicates the period of time which would have elapsed before the reservoir would again have been full.

It should be mentioned that the term "draft" as used in this discussion, represents an average prolonged withdrawal of water from the reservoir and includes losses due to evaporation and leakage.

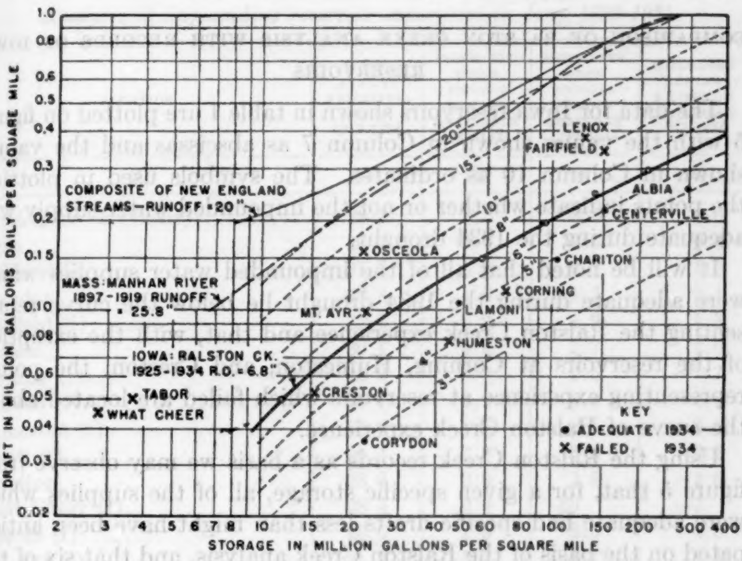

FIG. 5. ANALYSIS OF IMPOUNDING RESERVOIR REQUIREMENTS IN IOWA

Generalizations and Comparisons with Analyses for New England Streams

Having determined from figure 4 the storage requirements in million gallons per square mile for various drafts in million gallons daily per square mile, these data are plotted as abscissas and ordinates respectively in figure 5. The dotted curves shown in figure 5 which are parallel to the Ralston Creek curve have been drawn on the basis that, for a given storage in million gallons per square mile, the available draft in million gallons daily per square mile is directly proportional to the mean annual runoff for the particular watershed.

On figure 5 two curves are shown representing storage and draft

relationships, the one summarizing the experience of a composite of New England streams[1] for which the mean annual runoff was 20 inches, and the other representing a 23 year experience record on the Manhan River[2] in Massachusetts for which the mean annual runoff was 25.8 inches. The dotted curve which represents a proportional extrapolation of the Ralston Creek record to a mean annual runoff of 20 inches differs little from the curve representing the Manhan River experience, and, in general, lies between the two curves representing the experience for the eastern streams.

COMPARISON OF RALSTON CREEK ANALYSIS WITH RECORDS OF IOWA RESERVOIRS

The data for Iowa reservoirs shown in table 1 are plotted on figure 5 with the values shown in Column 7 as abscissas and the values shown in Column 10 as ordinates. The symbols used in plotting the points indicate whether or not the impounded water supply was adequate during the 1934 drought.

It will be noted that all of the impounded water supplies which were adequate during the 1934 drought lie below the curve representing the Ralston Creek experience and that, with the exception of the reservoirs at Corning, Humeston, and Creston, the points representing experience at reservoirs which failed are located above the curve of Ralston Creek experience.

Using the Ralston Creek records as a basis we may observe from figure 5 that, for a given specific storage, all of the supplies which were adequate had specific drafts less than might have been anticipated on the basis of the Ralston Creek analysis, and that six of the nine reservoir supplies which failed had actual specific drafts in excess of what might have been anticipated from the Ralston Creek records.

In retrospect and in an attempt to analyze in more detail the reservoir experience of southern Iowa during the critical period 1932 to 1934, inclusive, a correlation of all available data was made on the following basis: (The results of the correlation are shown in table 2 and in figure 6). The mean annual precipitation at or near

[1] "Report of Committee on Yield of Drainage Areas," *Journal*, New England Water Works Assoc., 28, pp. 397–555, 1914.

[2] P. J. Lucey, "The Holyoke Waterworks, and its Rainfall and Stream Flow Measurements," *Journal*, New England Water Works Assoc., 34, pp. 323–352, 1920, (Table 13, p. 346).

each reservoir was computed for the three year period, 1932 to 1934, inclusive. On the basis of the curve shown in figure 3 representing the relation between mean annual runoff for a given period and the mean annual rainfall for the corresponding period, an estimate was made of the mean annual runoff at each location for the period, 1932 to 1934, inclusive. During that three-year period the actual mean annual runoff observed on the Ralston Creek watershed was 3.5

TABLE 2

Analysis of impounding reservoir experience in Iowa 1932–1934

LOCATION	MEAN ANNUAL PRECIPITATION 1932-1934	ESTIMATED MEAN ANNUAL RUNOFF AVAILABLE 1932-1934	ESTIMATED MEAN ANNUAL RUNOFF REQUIRED 1932-1934	ESTIMATED RUNOFF EXCESS OR DEFICIENCY 1932-1934
(1)	(2)	(3)	(4)	(5)
Ralston Creek (Basis)	29.2	3.5	3.5	0.0
Albia	28.5	3.0	2.6	0.4
Centerville	31.0	5.0	3.1	1.9
Corydon	26.8	1.6	1.5	0.1
Fairfield (f)	32.5	6.2	4.9	1.3
Lamoni	30.1	4.3	2.7	1.6
Corning (f)	25.3	0.8	2.5	−1.7
Creston (f)	25.7	1.1	3.0	−1.9
Humeston (f)	26.8	1.6	2.1	−0.5
Lenox (f)	29.4	3.8	6.0	−2.2
Chariton	23.6	0.0	2.6	−2.6
What Cheer (f)	28.4	2.9	10	−7
Osceola (f)	28.0	2.5	6.5	−4.0
Mt. Ayr (f)	31.2	5.2	4.1	1.1
Tabor (f)	22.2	0.0	10	−10

(f) Indicates that impounded supply was inadequate in 1934.

Column (3) estimated on basis of Column (2) and curves of figure 3.

Column (4) obtained by multiplying 10-year runoff indicated by dotted curves of figure 5 by (3.5/6.8).

inches. That is to say, while the mean annual runoff from Ralston Creek over the ten-year period, 1925 to 1934, inclusive, was 6.8 inches, the mean runoff during the three driest consecutive years of record was only 3.5 inches.

The ordinates of the dotted curves shown in figure 5 are proportional to the ten-year mean runoff to be expected from Ralston Creek. In order to make the comparison of estimated mean annual

runoff which would have been required at each of the reservoirs under consideration during the dry period, 1932 to 1934, the values interpolated between the dotted curves for any particular reservoir were reduced in the proportion, 3.5 to 6.8, in order to correct on a proportionate basis for the mean amount of runoff which may have been expected to have been satisfactory during the three dry

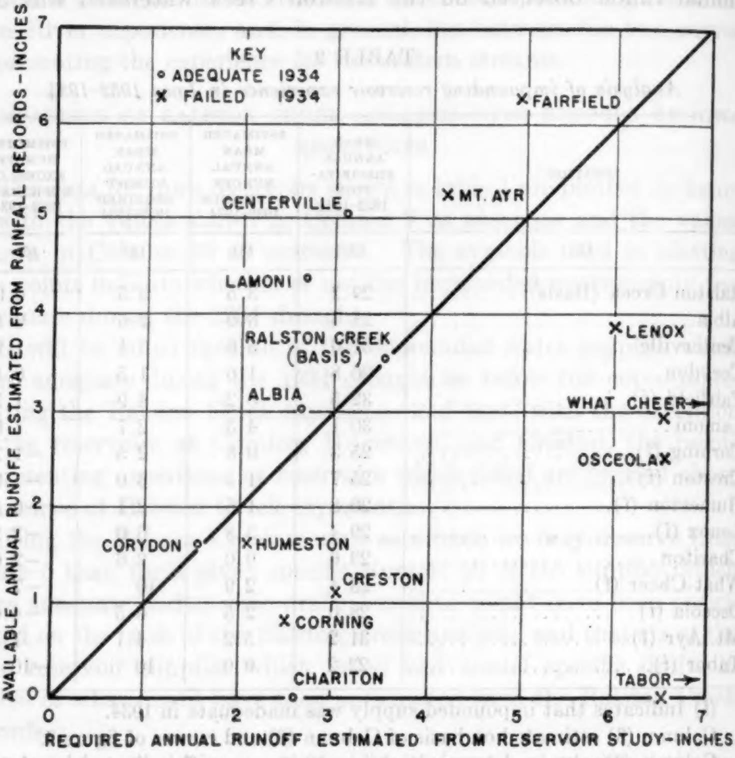

FIG. 6. ANALYSIS OF IMPOUNDING RESERVOIRS IN IOWA

years under consideration. The figures calculated in this way are shown in Column 4 of table 2.

The data shown in table 2 are plotted in figure 6. The ordinates show the available annual runoff estimated from the rainfall records while the abscissas show the required annual runoff estimated from the reservoir studies based on Ralston Creek records. Assuming this basis of analysis to be valid, it would be reasonable to expect that those reservoirs would have been satisfactory during the three-

year drouth period if the annual runoff actually available exceeded that required for adequacy. It will be noted from figure 6 that four of the five reservoirs which were satisfactory lie above the dividing line and that seven of the nine reservoirs which were unsatisfactory lie below the dividing line.

Only the Chariton reservoir proved to be satisfactory, although the available annual runoff estimated from the rainfall records for the three years was nil. Although it is not offered as an explanation of this discrepancy, it may be remarked that heavy showers which may replenish the reservoir supply during the critical period may modify in considerable detail any broad generalizations drawn on the basis of mean annual precipitation records for a three-year period.

CONCLUSIONS

The foregoing study may be summarized as follows:

1. An analysis of rainfall and runoff records for the Ralston Creek watershed near Iowa City, for the period 1925 to 1934 inclusive, is the basis of a relationship between draft and storage requirements for impounding reservoirs in Iowa and the Middle West.

2. A comparison of analyses for Ralston Creek and for certain streams in New England indicates that for a given storage per square mile of watershed the available draft per square mile of watershed is approximately proportional to the long-time mean annual runoff.

3. There is some evidence to indicate that the critical depletion period, during which the reservoir storage falls from its maximum to its minimum value, may be from two to five or more years for reservoirs in the central area.

4. For the Ralston Creek watershed there appears to be a well-defined relation between the rainfall occurring in three or more consecutive years and the corresponding runoff in the same period. This relation should be useful in estimating yields from similar watersheds during the critical depletion periods.

5. Using only the runoff records for Ralston Creek as a basis, the relationship obtained between draft and storage is consistent with the observations on all adequate reservoir supplies and on six of the nine inadequate reservoir supplies in southern Iowa. Taking into consideration the mean three-year rainfall, 1932–1934, near each reservoir site the analysis is consistent with observations on four of the five successful reservoirs and seven of the nine unsuccessful reservoirs.

ACKNOWLEDGMENTS

The rainfall and runoff data for the Ralston Creek watershed, used as a basis for this study, have been collected coöperatively by the State University of Iowa, the Bureau of Agricultural Engineering of the U. S. Department of Agriculture, and the Water Resources Branch of the U. S. Geological Survey.

B. J. Lambert is acting dean of the College of Engineering and administrative director of the Iowa Institute of Hydraulic Research and Prof. F. T. Mavis is associate director in charge of the laboratory. S. H. McCrory is Chief of the Bureau of Agricultural Engineering. D. L. Yarnell, senior drainage engineer of the Bureau, and R. G. Kasel, district engineer of the Survey, have coöperated with the University in compiling the basic hydrologic records.

(Presented before the Missouri Valley Section meeting, November 7, 1935.)

OBSOLESCENCE IN WATER WORKS EQUIPMENT AND OPERATING METHODS

By William W. Brush

(Editor, Water Works Engineering, New York, N. Y.)

It is generally agreed that the question of obsolescence in a water works plant is seldom raised as compared with an electric plant and there are some broad basic reasons for this condition.

Water supply is a non-competitive industry. There is no other industry selling a quantity product that is essential to the community life that is so generally in the non-competitive field. While financial competition may exist between the water supply that an individual industrial user may secure from wells on his property and the public water supply, such competition is very limited. You cannot drive in your auto to a neighboring town and obtain the water necessary for your home or business use. You must take what is brought to your door by your local system. This situation does not make for special alertness on the part of the water works management, but rather tends to develop the attitude of getting along with what one has instead of substituting something better.

General longevity and stability of water works structures minimizes equipment changes. Water works construction, including what is more generally termed equipment, has always been outstanding for its long life and water works financing has reflected this condition by the use of bonds with maturities up to fifty years to cover capital expenditures.

We, in the industry, have learned to think of our plant as one that will serve for decades and at times have failed to realize that, while this thought is correct for much of our plant, there are portions of the plant that are by no means unimportant, that should not be accepted as necessarily having a very long useful life.

Methods of operations have changed but slowly. Speaking with a background of forty years of intimate contact with the maintenance and operation of water supply systems, the writer is of the opinion that operating methods in the water works field have changed only slowly and that such observation holds true today. It is perhaps

desirable that this should be so in an industry upon which the protection of the health and property of the community depends. It is, however, possible that this conservatism might have gone too far towards "stand-patism" and should be modified by an aroused interest in the possibility of adopting improved operating methods.

High percentage of water plants are municipal. Some twelve thousand water supply plants are estimated to exist in the United States, of which about 80 percent are municipally owned. Those of you who have not operated a municipal plant would have difficulty in realizing how reluctant are the guardians of the municipal purse-strings to release funds to permit replacement of structures or equipment which have outlived their economic life, and in some instances have become a menace to the safety or continuity of the water supply. In privately owned plants, there is probably less resistance to replacing uneconomical structures, but here some resistance is to be expected to the engineer's or superintendent's plea that money be provided for replacements which will show no direct financial return.

With the background that has been developed, let us consider the various parts that make up a water works system with special reference to the question of obsolescence.

COLLECTION AND STORAGE OF WATER

Use of water supply lands and reservoirs for recreational purposes. Here we are immediately confronted with the controversial subject of whether the conservatism of the eastern water works men in trying to prevent the recreational use of water supply lands and reservoirs represents a method that is becoming obsolescent as compared to the view held by many western operators that such use is not to be discouraged, provided the sanitary quality of the water is safeguarded by adequate treatment. It is the writer's belief that gradually the recreational use will tend to prevail even though the cleanliness standard of the domestic water supply is thereby lowered, provided the sanitary quality of the treated water is fully maintained.

Today we have the copper sulphate treatment of stored water to destroy the algae content as the one most frequently and successfully used, but we know such treatment is applied by crude methods and either the use of copper sulphate or the method of application may become obsolete at any time.

In the equipment field, valves and their appurtenances are the

major items to which obsolescence may apply. In the older installations, hand valve operation is still generally found and today should be designated as obsolete and some form of mechanical operation installed, yet the water works men do not generally demand such modern aids to efficient operation.

TRANSPORTATION SYSTEM

While there have been notable changes in materials used and the design of water conduit systems, many of the conduits installed decades ago are still functioning satisfactorily and apparently can continue to do so for decades to come. Some of the minor equipment is obsolete and should be replaced but the main structure is still used and useful.

However, there is a condition in the water transportation field that is either not recognized or if recognized, not changed. That situation is the one where the transportation load on the conduit has become such that the frictional losses are uneconomically high and the failure to provide more adequate capacity becomes an obsolescent operating method.

Due to the development that has taken place in the successful automatic transmission of water level and pressure records over many miles, failure to utilize such modern aids may also represent obsolescent operating methods.

Where cast iron or steel transportation lines are exposed to an active water, the formation of rust tubercules and reduction in carrying capacity that follows, soon creates a situation where the cleaning and recoating of the interior of the pipe is without question an economy. Yet we all know of transportation lines which are in this condition and nothing has been done about it.

The City of New York has pipe lines ranging from 72 inches in diameter downward which, on a sound operating basis, should have been cleaned and recoated years ago but are still untouched, although recently this work has been started. This type of an obsolescent operating method is frequently not recognized and is one that the water superintendent usually finds difficulty in correcting on account of the expenditure required to overcome it.

Another type of obsolescent operating method is failure to use transportation conduit capacity effectively through lack of connections which might be inserted in the trunk main and deliver a more adequate supply for either fire or domestic supply or both.

In the writer's opinion, one of the most frequently encountered conditions that should be considered to represent an obsolescent operating method, but unfortunately often is not so considered, is lack of equipment to insure continuity of water supply if some part of the system should fail. This situation does not exist only in transportation systems, but may be found throughout all important parts of the entire water supply system. Even many of us who are in the water works field fail either to recognize or preach against such weaknesses. Whenever there is an opportunity to do so, our voice should be raised in favor of adequately safeguarding the continuity of the public water supply and we should urge the installation of structures and equipment necessary to accomplish the objective. Such objective should be a system, the service of which cannot be interrupted by any happening that can reasonably be foreseen as a probability, no matter how infrequent may be its actual occurrence.

DISTRIBUTION RESERVOIRS AND TANKS

When our attention is directed to distribution reservoirs, we immediately see a glaring case of what should be considered an obsolescent operating method but which is not yet generally so recognized. The writer refers to the open reservoir into which the winds carry the dirt from the surrounding territory, and the birds add their quota of polluting matter, especially in a location near large bodies of water like New York City, where the gulls, literally by the hundreds, fly from sewage laden waters and swim around on the surface of the reservoir from which one's drinking water is drawn. If even a crumb falls into the glass of water at the table, we wish to have the water replaced, yet millions of us drink water which is held in open reservoirs just before it is served to us.

Another drawback to the open reservoir is the opportunity given for microscopic organisms to develop with the attendant disagreeable tastes and odors that unfortunately are only too well known to many water works operators.

In our modern reservoirs and tank installations, we are avoiding the storing of water in the lower part of the structure at such a level that it is of little or no use. In many cases, it is impractical to change the old structures that have in them useless storage capacity.

In this part of the distribution system, we are again confronted with the question as to the need of distant control and recording mechanism and mechanical valve operation to avoid operating methods which should be considered obsolescent.

PIPE DISTRIBUTION SYSTEM

Here antiquated and what should be obsolete equipment and operating methods are frequently found.

A recent investigation of the carrying capacity of distribution mains throughout the United States showed that many of them no longer had more than approximately one-half to two-thirds of their original capacity due mainly to tuberculation. Yet many water works systems using an actively corrosive water are having pipes installed therein that are not adequately protected from corrosion in accordance with present day lining methods generally recognized as efficient.

The larger valves in the distribution systems in our cities are hand operated and take a half an hour or more to close after the water department gang arrives at the scene of a break which twenty minutes or so earlier released a flood of water which seriously damages property and interferes with the usual community transportation. Is not both the equipment and the usual operating methods in shutting down a broken water main obsolete? Valves are now available which can easily be closed in a few minutes irrespective of size. Should we not give more serious consideration to remote operation of important valves in our distribution system?

When we consider our fire hydrant locations, the design of the hydrants, their liability to freeze in areas where low temperatures occur, the size of the hydrant branch pipe and, in many instances, the absence of any valve on this branch, are we not again face to face with much that is obsolete both in equipment and in design?

MEASUREMENT OF SUPPLY FURNISHED TO CONSUMERS

In the United States, where water is considered to be a commodity to be sold at a price that will represent a fair return to the seller on the capital invested, it can properly be said that delivering water on a flat rate basis should be considered an obsolescent operating method. On the other hand, in Great Britain, water is considered to be a necessity of life and is to be paid for not on the basis of a commodity to be sold at a moderate profit but on the basis of the ability of the individual to pay for this life necessity. On the English theory, meters on residences are not considered necessary or proper. As a result, a middle class English family of three persons may pay $60 a year for water while the unskilled laborer with a family three times as large may pay $6 a year as the water charge is generally 6 percent of the annual rental of the property occupied.

In America where water meters are so generally used, one will find numerous instances where the meter equipment is in part obsolete and the methods of test and upkeep of these water cash registers are also obsolete. In one community, where the annual water collections are about two and one-half million dollars, the superintendent estimates that there is an annual gain in revenue of from \$60,000 to \$70,000 due to testing the meters in a certain manner on five different rates of flow as compared with testing them at the high and low flow limits.

Again it is not unusual to find meters on premises of a size entirely unsuited to measure the water accurately at the rate of flow at which most of the consumption demand takes place.

PUMPING STATIONS

While some water systems are strictly gravity delivery, most of us have been called upon to operate one or more pumping stations as part of our system. While much of the equipment is reliable not as much can be said for its economy. Only a few years ago, the city of New York removed a 15 m.g.d. engine and pump that was installed over sixty years ago. The old machine was still reliable, but had been obsolete for several decades. In a driven well pumping station having a capacity of 5 m.g.d., the test pumps installed by the contractor for temporary use were kept in place for about thrity years. These pumps were only operated intermittently, but even with such operation, their earlier replacement would have been true economy. Many instances could be given where the replacement of an old pumping engine has shown an operating economy that would pay for the new machine in a few years' time.

WATER TREATMENT PLANTS

Here we come into a division of water supply which has probably shown greater changes than any other one. The writer holds that equipment and operating methods which fail to produce a water that is satisfactory to the consumers should usually be considered obsolete. Have we not reached the period when we should advocate treatment of water that will make it not only a safe water but one that is at all times palatable, satisfactory for household and commercial use and inactive when in contact with the delivery pipe system? Some water supplies have been so thoroughly studied, experimented with and treated that they meet all the above specifications, but such supplies are relatively few.

GROUND WATER DEVELOPMENTS

The writer has been intimately connected with one of the largest ground water developments for use for a public water supply. From Long Island, N. Y., approximately 200 m.g.d. are at times drawn from sub-surface sources for public water supplies. Wells of many types have been used both there and elsewhere, starting with the dug well and extending to the gravelled wall well as the most modern type. Undoubtedly many of the wells in use are of an obsolete type, but here one must use caution in making generalization as the well that is suitable for one set of soil and water conditions is not suitable for another set of conditions. There is no question that some of the operating methods, together with the wells themselves, are obsolescent, but a careful investigation of each installation is necessary to pass judgment correctly.

CONCLUSION

The writer trusts that he has not given the impression that water supply systems in the United States are generally out of date or are inefficiently operated. He does wish to impress upon water works operators the desirability of developing a questioning attitude and willingness to advocate change to up-to-date equipment and operating methods where the community served would benefit from such changes either financially or through having a more dependable and satisfactory water supply.

Our obligation to our public calls for mental alertness and readiness to give up the old and take on the new if the facts justify such action.

(Presented before the Southwest Section meeting, October 14, 1935.)

A SURVEY OF POTENTIAL HEALTH HAZARDS DUE TO FAULTY PLUMBING

By W. Scott Johnson

(*Sanitary Engineer, Health Division, St. Louis, Mo.*)

Due to faulty plumbing and the resulting contamination of the water supply of two hotels, a dramatic and disastrous epidemic of amebic dysentery occurred in Chicago in the Fall of 1933. To date (January, 1935) approximately 1,000 cases of amebic dysentery and 58 deaths have been recorded. This epidemic emphasized much more emphatically the dangers of faulty plumbing to health than any other occurrence or innumerable reports in the past. Health officials throughout the United States were confronted with a potential situation of an extremely hazardous nature that could not be safely ignored in view of the Chicago experience. An official preliminary report of the Chicago amebic dysentery epidemic appeared in the February 3, 1934, *Journal of the American Medical Association.* It contained the following recommendations:

"1. Sanitary engineers have for years recommended, and the laws of practically every state and municipality provide, that water and sewer installations should be so arranged as to prevent absolutely contamination of water supplies for domestic use by water of nonpotable quality.

"The committee recommends that attention be called again to this extraordinary hazard and necessity of rigid enforcement of these regulations.

"2. No physical connection should be permitted between water systems that are safe for domestic use and those that are unsafe for domestic use. There should be no provision for a connection or arrangement by which unsafe water or sewage may be discharged or drawn into a safe water supply system.

"3. An exhaustive and searching study of the whole water and sewage systems of hotels with antiquated plumbing should be made and any defects immediately corrected. This work should be done by competent sanitary engineers.

"4. The present conditions, under which, during periods of flood, flood waters from the street can reach and cause an overflow of sewage in the basement of any hotels, should be thoroughly investigated by officials having jurisdiction, and methods adopted to prevent such an occurrence. Unless the antiquated plumbing and conditions of food handling found in Hotels C and A are remedied, there seems to be no warrant that a recurrence of the outbreak here considered may not develop under similar conditions."

It is well to recall that previous to the Chicago epidemic the American Water Works Association, Conference of State Sanitary Engineers, New England Water Works Association, the Federal and many state health agencies passed prohibitory resolutions and regulations against cross-connections and faulty plumbing as a public health hazard. The actual observed health hazards, beside the Chicago disaster, resulting from cross-connections and faulty plumbing, were indicated by the record of 29 water-borne epidemics in the United States between 1920 and 1929 causing 8530 cases of typhoid and dysentery.[1]

J. I. Connolly, Sanitary Engineer of the Chicago Health Department, briefly sums up the hazards more recently demonstrated in faulty plumbing connections as follows:

"1. Every plumbing fixture directly connected to a water pipe or stack in the plumbing system is a part of that system, and the sewage may back up into the fixture in case a stoppage occurs.

"2. Water held in fixtures and traps may be contaminated in the course of their customary use, as well as by backing up sewage.

"3. If the water inlet to the fixture be submerged in such contaminated water or sewage, the reduction of the water pressure, in the inlet pipe to a valve, lower than the static head, will cause, upon opening the inlet valve, a return flow of the fixture contents into the drinking water supply pipe.

"4. Self-closing valves actuated by the water pressure in the supply pipe, such as the common types of flush valves for toilets, become self-opening valves when the positive water pressure becomes changed to a negative pressure or partial vacuum.

"5. The partial vacuum in a supply pipe is a common occurrence in many localities due to (*a*) excessive use of water at lower elevations, (*b*) insufficient pumping capacity, (*c*) heavy draught upon fire hydrants in the vicinity of fire engines, (*d*) shutting off the supply while making repairs, and to other common occurrences.

"6. In large buildings, especially, there is no ready means for the user of a fixture to determine definitely in advance whether a positive pressure or a partial vacuum exists in the supply pipe. The valve is opened and if there is no pressure, one simply waits for water. In large areas of Chicago this condition exists upon the third floors of many buildings during the hours when lawns are being sprinkled on warm days."

The dangers revealed by the careful and extensive work of the Chicago Health Department have caused at least two national organizations to pass resolutions which require a guarantee for the safety of any hotel in which they may hold future conventions.

[1] The Significance of Water-borne Typhoid Fever, Wolman and Gorman, The Waverly Press, Baltimore, Md.

Engineering News-Record, June 14, 1934, comments editorially as follows on the action taken by the American Water Works Association.

"In a dramatic way, emphasis has again been placed upon the hazard to health presented by faulty building plumbing by the decision of the American Water Works Association to demand from convention hotels in the future definite assurance that contamination cannot enter the drinking water supply through badly arranged or poorly maintained piping. Although the organization, like the New England Water Works Association and, the American Public Health Association, has for many years combated the cross-connections of potable water supplies with any other piping systems, its attention was forcibly directed to the dangers of exposing purified water to contamination within the interior of buildings by the analysis presented during the convention of the physical background of the amebic dysentery epidemic that focused at Chicago last year. That an organization whose activities are so closely bound up with problems of public health should demand assurance of safety from the hotels it patronizes is entirely proper. It is to be hoped that other organizations will follow the example."

The Board of Directors of the American Society of Civil Engineers passed the following resolutions in July, 1934:

"That in the future the American Society of Civil Engineers, or its Board of Directors, hold no meeting in any hotel without first obtaining satisfactory assurance of the hygienic safety of its water supply."

The preceding constitutes a very brief historical sketch of the more recent developments relative to faulty plumbing. Whether or not water works officials are, or will be to some degree, responsible for all such hazards to health, as are classified under faulty plumbing, piping and cross-connections, it was believed that from a broad view point these problems should be of vital interest. Sometimes it becomes difficult to decide, particularly under operating conditions, where a water supply ends and a sewer system begins. It is further doubtful whether water works officials can be sure where their responsibilities for safe water ends. Can they, for example, logically say that it ends with the curb shut-off valve? There seems to be added reasons for considering the water and sewer systems as one single utility designed to provide satisfactory sanitation wherever humans live, work or play and, in the future, to scrutinize them more carefully as a complete unit rather than two separate ones, as has been usually the case in the past. With the belief that the water works official is necessarily concerned with these problems,

this discussion of a survey of faulty plumbing in various types of buildings is presented.

SCOPE AND PLAN OF SURVEY

The work was undertaken as an FERA project with a group of engineers of varying experience. It was planned to survey several buildings used for the following purposes: swimming pools, hotels, milk plants and hospitals, since these probably presented the greatest potential hazard to public health. While the entire program was planned on the basis of an investigation or demonstration, as required by the FERA, never-the-less, it was deemed necessary to do the work in a systematic, thorough manner, otherwise many typical defects in the types of buildings chosen might be missed and the purpose of the survey defeated. Consequently, no attempt was made to cover a large number of buildings, but rather to survey thoroughly a few places representative of each of the several classes of structures chosen.

Although graduate engineers were available for making the surveys it was realized the men were totally unfamiliar with sanitary engineering methods and technique. Therefore, considerable time and effort were spent in training the men by lectures, field inspections and literature available on the subject. Further, the survey blanks for recording information were carefully prepared and a system of standard sketches of piping systems devised so that defects could also be shown and checked diagramatically. In the beginning it was arranged that each investigator spend ample time with an experienced man so that the details of the work were thoroughly understood. Weekly or more frequent conferences were held with all the men in attendance at which time points in question were thoroughly discussed. Upon the completion of any plant the investigators working in pairs drew up a report of their findings, in addition to the survey sheets and drawings. With these data available the work was completely field checked by the most competent and experienced men in direct charge of this work. Samples of potable water supply were collected from several outlets in each building during the survey and analyzed bacteriologically.

Before undertaking the survey of any buildings the city department, or business organization concerned, was contacted, the purpose of the work explained, and permission for undertaking the survey secured. For example, the Hospital Commissioner and Supervisor

Milk Control approved the survey of city hospitals and milk pasteurization plants, respectively, and the Hotel Association approved the survey of hotels.

Engineers making the surveys were allotted, in accordance with FERA regulations, a varying number of work days each month. This obviously did not lead to maximum efficiency, but was an unavoidable condition.

Table 1 indicates numerically the number of engineers and clerical help assigned to this survey, number of man days, number of man working hours and cost in salary each month for duration of this project. It will be noted that the fewest number of men were working during September and the greatest number were available in

TABLE 1

Total personnel—engineers, draftsmen and stenographers, hours of work and salary cost

MONTH	NUMBER OF MEN EMPLOYED	NUMBER OF MAN WORKING DAYS	NUMBER OF MAN WORKING HOURS	SALARY COST
September	5	70	434	$373.44
October	14	144	924	866.40
November	17	235	1,440	1,403.04
December	20	274	1,590	1,559.04
January	10	136	845	776.84
Total		859	5,233	$4,978.76

December. This wide variation was due to method of assignment by the Local Relief Office. Likewise, the number of man hours and cost per month varied greatly. The total number of man hours spent on the project was 5233 and the cost in salaries was $4978.76.

The division of the time spent is shown in more detail in tables 2 and 3. The former indicates the time consumed and cost for such items as initial training supervision, checking, stenographic help, etc.

Table 3 indicates the time and cost of each survey made. Only the time and cost of FERA engineers field work on this project are included in table 3. Considerable time of the author, spent in supervision and also tabulation of the data as presented in this report, has not been included in the cost of the project.

RESULTS OF SURVEY

In order to give to those interested an accurate picture of the conditions found as regards plumbing defects in buildings and the many

TABLE 2

Time and cost of training personnel, supervision, contacts, drafting and clerical activities

TYPE OF WORK	MAN HOURS REQUIRED	SALARY COST
Training	108	$112.32
Supervisor	378	393.12
Contact and Educational	180	187.20
Tabulating	18	18.74
Checking	66	68.64
Drafting	612	385.56
Stenographic	474	280.32
Total	1,836	$1,445.90

TABLE 3

Types and number of buildings surveyed, time required, and cost of field work

BUILDING	PER CENT COMPLETED	MAN HOURS REQUIRED	SALARY COST
Swimming Pools (thirty-eight)	100	594	$617.76
Hotel "A"	100	343	356.72
Hotel "B"	100	96	99.84
Hotel "C"	100	132	137.28
Hotel "D"	100	144	149.76
Hospital "A"	100	438	455.52
Hospital "B"	75	480	499.20
Hospital "C"	100	228	277.12
Hospital "D"	100	336	349.44
Dairy "A"	100	114	118.56
Dairy "B"	100	54	56.16
Dairy "C"	100	60	62.40
Dairy "D"	100	36	37.44
Dairy "E"	100	36	37.44
Dairy "F"	60	306	318.24

factors involved, the summarized data are presented in tables 4 to 10 inclusive. For simplicity, and to facilitate tabulation, however, subject to certain criticisms, the defects have been grouped

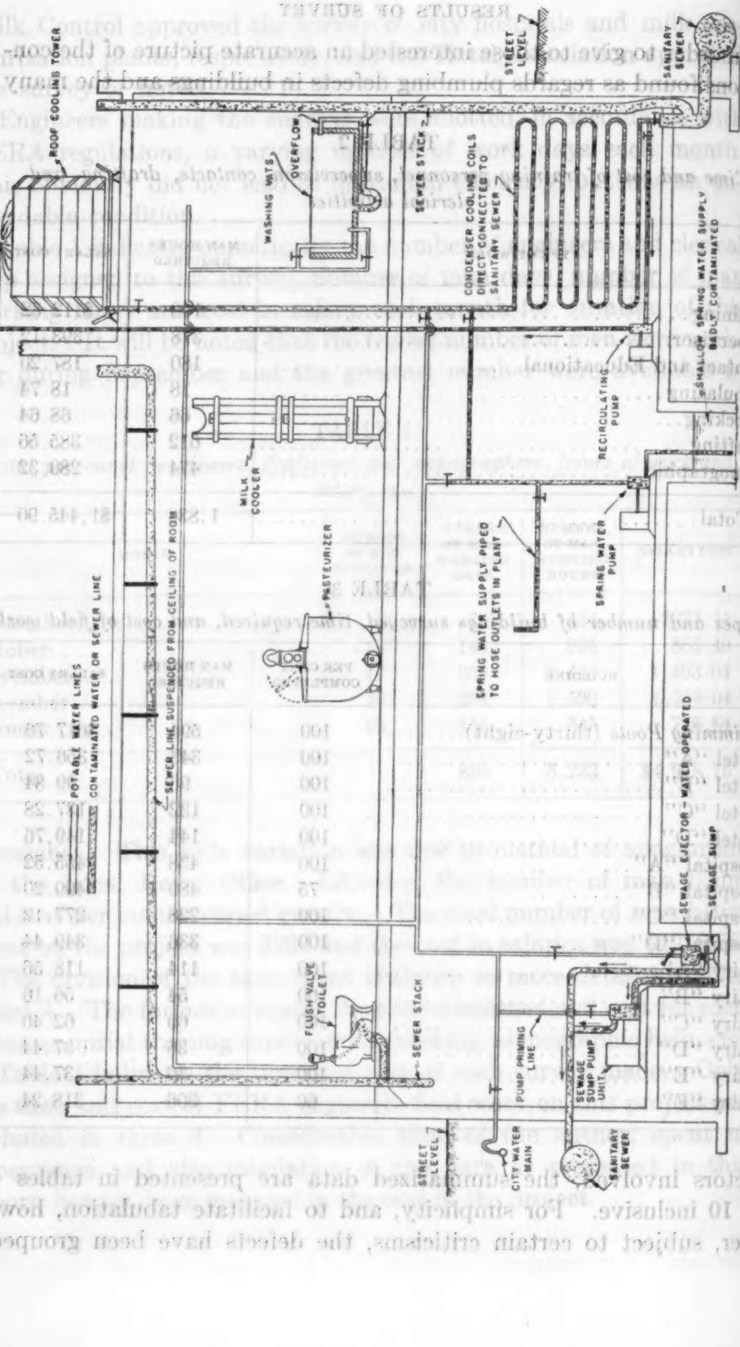

FIG. 1. SKETCH SHOWING TYPICAL TYPES OF UNSAFE PLUMBING CONNECTIONS

into seven general types according to the way in which the conditions become a plumbing defect and health hazard as follows (see figure 1).

Type 1. Direct pipe connection between potable water supply and sewage, or other contaminated water, with or without check or manual valve between, which through excessive back pressure or negative head, or both, might result in the contamination of the potable supply by sewage or polluted water. Example Type 1: Sewage or waste water pumps directly connected to potable water supply for priming purposes, or for use in dual capacity of pumping either contaminated or potable water; condensers direct connected to potable water supply and also to sewer lines; drains or overflow from potable water tanks direct connected to sewer lines; water softeners direct connected to sewer lines; mechanical refrigerating units direct connected to potable water supply and sewer lines.

Type 2. Potable water supply inlets constantly submerged, or submerged because of direct or indirect stoppage that, due to a negative head or vacuum in the potable water supply lines might result in the contamination of the potable water supply with sewage or polluted water through back siphonage. Example Type 2: Constantly submerged inlets which are hazardous, even when the fixtures are in good operating condition. Siphon jets in water closets and urinal traps, laundry washing machines, swimming pools, instrument sterilizers, jets in bottom of water closet bowls used for washing bedpans, bell supply bath tubs, including the therapeutic tubs, water baths for many purposes, hydraulic lifts, processing tanks, bidet fixtures, filters, softeners, stock-water basins. Inlets not ordinarily submerged beneath the surface of the fixture contents, but which at times become submerged due to carelessness in filling or to stoppage of outlets. Flushing rim openings in water-closets, urinals and slop sinks, lavatories, bath tubs, utility room sinks, dish-washing machines, spray heads in air washer, drinking fountains, bedpan sterilizers.

Type 3. Sewer or waste lines so located that their leakage due to corrosion or defect, and floor drains in refrigerators or other rooms where food or ice is stored located so that back flow, would result in the contamination of food, drinking water, ice, etc. Example Type 3: Sewer lines located over potable water tanks, food preparation tables, food storage shelves, food processing equipment, such as pasteurizers, milk coolers and cookers, floor drains located in

TABLE 4

Number of plumbing defects in each hotel surveyed classified according to types

HOTEL	NUMBER OF PLUMBING DEFECTS FOUND						AGE OF BUILDING
	Type 1	Type 2	Type 2	Type 4	Type 5	Total	
							years
A	5	1,156	8	2	7	1,178	32
B	0	301	1	0	0	302	11
C	5	1,220	11	0	6	1,242	19
D	1	300	0	2	0	303	7
Total 4	11	2,977	20	4	13	3,025	

TABLE 5

Number of plumbing defects in hotels classified according to type and equipment involved

EQUIPMENT	NUMBER OF PLUMBING DEFECTS FOUND						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Total
Air Conditioning........		6					6
Bath Tub........		800					800
Coffee Urn........		2					2
Condenser........	3						3
Dish Washer........		3					3
Drinking Fountain........		7			13		20
Flush Toilet........		1,760					1,760
Floor Drain........			7				7
Food Mixer........		1					1
Glass Washer........		1					1
Laundry Tray........		7					7
Loose Hose........		6					6
Potable Water Tank........	2			4			6
Potato Peeler........		1					1
Pump........	4						4
Sewer Pipe........			13				13
Soap Kettle........		2					2
Steam Table........		1					1
Wash Bowl........		380					380
Water Softener........	2						2
Total........	11	2,977	20	4	13	0	3,025

refrigerators, or other rooms where food is stored, or in rooms where ice is made or prepared for use.

Type 4. Water supply subject to aerial pollution. Example Type 4: Potable water supply tanks with open or loose tops located on roof of building or elsewhere within buildings.

Type 5. Possible infection of persons through use. Example Type 5: Faulty designed drinking fountains which can be contaminated by user and result in a hazard to subsequent users.

Type 6. Equipment designed to hold food during processing, surrounded by or containing pipes or jacket through which the water supply is circulated. Frequently this type of equipment is rinsed with tap water just previous to use. The danger from such connection is predicated upon the water supply becoming contaminated

TABLE 6

Number of plumbing defects in each hospital surveyed classified according to types

HOSPITAL	NUMBER OF PLUMBING DEFECTS FOUND						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 7	Total
A	1	348	13	2	3	25	392
B	2	483	13	2	2	5	507
C	1	106	0	0	0	3	110
D	3	176	4	0	5	0	188
Total....4	7	1,113	30	4	10	33	1,197

due to other faulty plumbing and the development of breaks in the pipes or jacket so that contaminated water would leak into the food supply. Example Type 6: Certain type of milk pasteurizers, milk holding vats, milk coolers, and other equipment in which dairy products are heated or cooled, or both.

Type 7. Direct unbroken connections between hospital equipment used in providing sterile water, instruments and bandages and sewer or waste lines with or without check or manual valves between so that due to excessive back pressure or negative head or both the sterile material may unknowingly become contaminated. This type also frequently falls into Type 2 when the water supply might become contaminated. Example Type 7: Instrument sterilizers, water sterilizers, bandage sterilizers, infant food sterilizers, etc.

TABLE 7

Number of plumbing defects in hospitals classified according to type and equipment involved

EQUIPMENT	NUMBER OF PLUMBING DEFECTS FOUND						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 7	Total
Autoclave	1						1
Autopsy Sink		3					3
Autopsy Table		5					5
Aspirator		9					9
Baby Spray		2					2
Bath Tub		153					153
Bed Pan Sterilizer		10					10
Bed Pan Hopper		13					13
Boiler Blow Off	1						1
Brine Tank		1		1			2
Cooking Kettle		18					18
Condenser		2					2
Dish Washer		12					12
Drinking Fountain		10			10		20
Fish Pond		1					1
Floor Drain			4				4
Flush Toilet		471					471
Hot Water Heater	2						2
Hydraulic Elevator	1						1
Instrument Sterilizer		21	1			21	43
Laundry Tray and Washer		5					5
Loose Hose		83					83
Potable Water Tank				3			3
Potato Peeler		1					1
Pump	2						2
Sewer Pipe		1	25				26
Sink		25					25
Solution Tank		1					1
Steam Cooker		2					2
Steam Kettle		3					3
Sump		1					1
Wash Basin		247					247
Water Softener		1					1
Water Sterilizer		12				12	24
Total	7	1,113	30	4	10	33	1,197

Swimming pools

To present the data secured from a survey of the plumbing and piping at 38 swimming pools, it is desirable to group the defects under different types of hazards because of specialized conditions of equipment and operation. The four general types pertaining to swimming pools, grouped according to the way the plumbing defect becomes a public health hazard, are described as follows:

Type 1. Direct unbroken connection between potable water supply and sanitary sewer with or without check or manual valve between, through some piece of equipment, such that excessive or negative head or both might result in the contamination of the potable water supply with sewage. Example Type 1. Pool recirculation water pump, filter back wash direct to city main, filter to waste unbroken connection to sanitary sewer.

TABLE 8

Number of plumbing defects in each milk plant surveyed classified according to types

MILK PLANT	NUMBER OF DEFECTS FOUND						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Total
A	4	35	1	3	4	12	59
B	0	13	0	0	0	1	14
C	0	21	1	1	0	14	37
D	0	13	2	0	0	9	24
E	0	10	2	0	0	3	15
F	4	43	0	5	5	4	51
Total. . 6	8	135	6	9	9	43	210

Type 2. Solid connection between pool and sanitary sewer, under conditions such that back pressure in the sewer line might result in pollution of the pool water with sewage. Example Type 2. When pools are located in basement, flooding of street sewer may create sufficient head to force sewage into pool when empty or even when full through pool drain.

Type 3. Solid connections between potable water and pool water such that contamination of the city water might result from back siphonage or excessive pressure on the pool water side. Example Type 3: Direct connection of potable water to filter for washing, or connection to pool circulating system for make up water.

Type 4. Potable water supply inlets constantly, or occasionally submerged so that contamination of the potable water might result due to back siphonage. Example Type 4: Make up water or spray inlets into pools.

TABLE 9

Number of plumbing defects in milk plants classified according to type and equipment involved

EQUIPMENT	NUMBER OF PLUMBING DEFECTS FOUND						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Total
Bottle Sterilizer		2					2
Bottle Washer		4					4
Brine Tank		2					2
Can Washer		5					5
Case Washer		2					2
Cheese Tank						2	2
Condenser		2					2
Culture Tank		6				5	11
Drinking Fountain		5			9		14
Floor Drain			2				2
Flush Toilet		25					25
Hose		51					51
Laundry Washer		2					2
Milk Cooler						4	4
Milk Condenser	1					1	2
Milk Storage Tank						2	2
Pasteurizer						29	29
Potable Water Tank				7			7
Pump	5						5
Refrigerator	1						1
Roof Cooler				2			2
Sewer Pipe	1		4				5
Soaking Tank		1					1
Steam Cooler		4					4
Sterilizer		1					1
Wash Bowl		15					15
Wash Tank		7					7
Water Softener		1					1
Total	8	135	6	9	9	43	210

Study of the tables will provide a fairly complete detailed picture of what may be, in general, expected with regard to the type and prevalence of faulty plumbing in the average city. In the four hotels surveyed there was a total of 3025 defects found classified into five

general types according to the way in which the defect becomes a health hazard.

Hotel defects

Numerically, Type 2 defect predominates, due to the large number of bath-rooms in modern hotels and the prevalence of flush valve toilets, and submerged water inlets in conjunction with wash bowls and bath tubs. It is of interest to note the direct influence of the age or the hotel on the number of defects found. There are 20 different types of equipment intimately involved and to that degree responsible for the defects found. It should be particularly

TABLE 10

Number of plumbing defects in swimming pools classified according to type and equipment involved

EQUIPMENT	NUMBER OF PLUMBING DEFECTS FOUND				
	Type 1	Type 2	Type 3	Type 4	Total
Chlorinator			14		14
Filter	9				9
Filter Back Wash			15		15
Hot Water Tank			1		1
Ozonator	1			2	3
Pool Drain	1	54			55
Pool Water Heater	2		7		9
Pool Water Inlet			3	62	65
Pump—Recirculating	15				15
Sewage Pump	1				1
Total	29	54	40	64	187

noted that in 11 instances equipment was direct connected to sewer, or contaminated water lines, and potable water lines where it was not even necessary for back siphonage to occur to bring about contamination of water supply. A leaky valve and positive pressure on the sewer lines, due to a stoppage, a pump or sur-charging would result in sewage reaching the water supply.

Hospital defects

The survey of the hospitals indicated 1197 plumbing defects that have been classified into six general types according to the manner in which the defect becomes a health hazard. There are 34 different

kinds of equipment involved with the hazardous cross-connections found, many of these peculiar to a hospital, such as autopsy table, sterilizers, bedpan hoppers, etc., otherwise the situations were not greatly different from those found in hotels. It is of interest to note that in 33 instances equipment used for sterilizing was found so connected that supposedly sterile material could be contaminated with sewage.

Milk plant defects

The survey of six milk plants indicated the existence of 210 plumbing defects. There were 28 different kinds of milk plant equipment involved in the hazardous connections found. In 152 instances the plant water supply was subject to possible contamination. Forty-three pieces of milk equipment were found with water jackets or coils which, in case of a leakage, would allow the plant water supply to come into contact with the milk.

Swimming pool defects

The survey of 38 swimming pools indicate 187 plumbing defects that have been classified into four general types according to the manner in which the defect becomes a health hazard. There are 10 different kinds of equipment involved in the hazardous connections found.

Samples of water were collected from taps in several of the buildings surveyed. In two instances these samples indicated bad contamination. In one case the samples were collected from an auxiliary spring water supply. This supply was cross-connected with the city water supply within the building. In the second instance the sample was taken from water being used to cool milk.

DISCUSSION

The results of this survey indicate a number of ways in which the water supply, food products, hospital equipment and swimming pool water might be contaminated due to faulty plumbing installation and equipment design. These piping or plumbing defects usually exist because of a direct connection between the potable water supply and other piping systems, or a possible submergence of a potable water outlet or faucet in contaminated water or sewage. When direct piping connections exist it is easy to visualize the danger due to greater pressure occurring in the contaminated lines. It is

recognized that at least a partial vacuum may exist without warning in any water piping system due to a number of causes, such as a heavy draft on a main from fire lines, or cutting off the water supply and draining lines for repairs. Such a vacuum has, for example, been shown capable of siphoning out the contents of various equipment into the water lines, including a flush valve type toilet bowl in good working order.

Usually the only means of protecting water lines direct connected to contaminated water or sewer lines against a vacuum in the potable water lines, excessive pressure on the non-potable water side from a pump, or back pressure due to temporary stoppage or sur-charging in a sewer line, has been by means of a check or manual valve. The ease and frequency with which these types of valves are made ineffective, due to corrosion, stoppage by foreign material, or even tampering by the careless or uninformed, render such protection very unsatisfactory. In general, these characteristics of piping or plumbing systems are responsible in a great variety of modifications for most of the existing potential hazards of plumbing conditions revealed by this survey.

The nature of this pollution may be heavy and possibly continuous, or slight and intermittent. However, in any case, the large number of defects found in the buildings surveyed gives some indication of the probable frequency of such contamination occurring. Obviously, certain types of defects are more dangerous than others. Direct connections between water supply and sewage through pumps or pipes which may produce a considerable pressure on the sewage side, in addition to possible vacuum on the water side, are probably the most dangerous. On the other hand, back siphonage of flush toilets, which has been repeatedly demonstrated with fixtures in good working order, may result in the introduction of highly infective material into the water supply line, and must also be considered one of the most hazardous types.

Faulty connections or plumbing in certain types of buildings present a greater hazard than in others. The pollution of a water supply in a milk plant and subsequent leakage of this polluted water supply into a large quantity of milk after pasteurization, for example, during cooling, would subject many hundreds of persons to a contaminated milk and possible disease. Conversely, a faulty hospital sterilizer causing the contamination of supposedly sterile operating instruments, would probably infect a relatively few persons, although under more fatal circumstances.

In the majority of instances where defective plumbing was found the contamination of the water supply would be a possible, if not a probable occurrence. This contamination would undoubtedly be most severe in the water supply of the building. However, in many instances there is danger of the contamination not being confined to the building, but reaching the general water supply of the locality. The defects found at swimming pools might result in the contamination of the pool water, or the general water supply with sewage or swimming pool water. In either case a large number of persons will be exposed to disease.

Additional factors of considerable importance on the possibility of a health hazard occurring are the age of the building and equipment and maintenance of plumbing and other equipment. Old plumbing badly corroded and lacking many modern safe-guards, as well as a poorly maintained piping system present particularly great potential hazards. In the case of plumbing from 20 to 25 years old, a complete renovation is in order due to obsolescence, if for no other reason. Beside defective plumbing, this survey indicated that in many cases equipment of various types is improperly designed and, therefore, frequently responsible for the health hazards found.

The necessity, as well as the reasons for keeping sewage or human fecal material from all contact with food or a potable water supply, for the purpose of protecting public health, is too well understood by water works officials, as well as the public, to require further discussion in this report. For the protection of public health from the so-called filth borne diseases, immense sums for capital outlay, as well as for maintenance, are expended yearly by our cities in order to provide adequate safe collection and disposal of sewage and a safe water supply, conveniently piped within buildings. Notwithstanding these expenditures and other important precautions for the protection of public health, a weak link in the protection chain has been recognized for a number of years by sanitary engineers. This point of weakness, as also definitely demonstrated in other cities, is due to the failure in the past to separate absolutely potable water supplies from sewer lines and protect food from possibility of contamination by sewage.

As demonstrated by the results of this survey, there are many more or less obscure or indirect connections in our hotels, milk plants, hospitals, swimming pools, and undoubtedly, other build-

ings, between the water supply, food processing equipment, and dangerous polluted substances such as contaminated water and sewage. Once again the sanitary chain of protection provided for the benefit of our citizens is no stronger than the weakest link. All the precautions and expense involved in providing a safe water supply to the building service is liable to a large degree to be wasted under present conditions of possible contamination of the water supply by sewage within the buildings.

Many circumstances concerning the epidemiology of filth borne disease, particularly in non-epidemic form, has continued to baffle health authorities. It seems reasonable that many unexplained cases of typhoid fever, particularly the rise in the rate following the summer vacation period, when many persons are traveling and living in hotels, may be correctly attributed to the rather universal existence in all cities of these faulty plumbing connections.

The remedy of hazards due to faulty plumbing, presents a problem that from the technical standpoint appears not to be difficult. However, the converse is true from the administrative standpoint. All defects found can be remedied, many very easily and at a minimum cost. The administration, however, of a program for eliminating existing defects and preventing new ones in future installations presents greater difficulties and will require time and patience for its solution. Nevertheless, by concentrating on those defects and places which present the greatest hazard to the largest number of persons, and with dependable personnel, progress will be realized. In making recommendations for the necessary plumbing changes it is essential that the personnel charged with the responsibility be thoroughly trained so that sound authentic advice can be given which will eliminate entirely all defects. For this purpose men with a knowledge of the hydraulics of sewer and water lines, as well as intimate knowledge and acquaintanceship with the purpose and operation of equipment involved. is absolutely necessary.

The fact that faulty plumbing connections constitute a distinct health menace, obviously places a direct responsibility upon the health department. In fact, the inspection of plumbing can only be justified on the grounds of health protection, and when defective features from the health standpoint are allowed to be incorporated into the plumbing within buildings, the entire purpose of the supervision over plumbing has been invalidated. Consequently, in view of past occurrences, and present findings, the health department

cannot escape responsibility relative to a condition that involves so many potential hazards to public health as faulty plumbing.

One further point must be emphasized, namely, the need for constantly checking plumbing conditions to be certain that faulty connections are not installed by individuals not acquainted with the dangers involved. Frequently, janitors, mechanics or handymen are called upon to make changes in the plumbing or water supply of a building, the dangers concerning which they have no knowledge and, consequently, take no precautions.

The data presented by this survey could be discussed at much greater length, and in more detail, both as regards the essential features of each type of connection and the nature of the remedy best to apply. Many precautions to be taken in design and installation of plumbing could also be emphasized by various faulty conditions encountered. However, such is not the purpose of this report and, consequently, more detailed discussion is reserved for possible subsequent reports.

In concluding this discussion it is believed conservative to say that probably no greater sanitary hazards than faulty plumbing connections, have been demonstrated since the initial need for safe water supply and adequate sewage disposal was definitely understood. It seems further safe to conclude that no city is free from these hazards to public health, that they constitute a real and definite responsibility of city health departments and probably water departments, and an immediate and aggressive effort must be initiated toward their elimination.

CONCLUSION

First. Past, and particularly more recent investigations, of the danger to health from faulty plumbing within buildings indicate beyond a question of doubt the responsibility, as well as potentialities, of such defects for causing such filth-borne diseases as dysentery and typhoid fever.

Second. A survey of plumbing within representative types of buildings indicated that probably in all of our cities many plumbing defects exist, which past experience indicates will, under not unlikely circumstances, cause the dangerous contamination of water and food with the resulting exposure of individuals to pathogenic organisms. Further, this survey was sufficiently extensive to conclude that the existence of such defects is prevalent in buildings used for

numerous purposes and, undoubtedly, exists in buildings constructed for residential purposes, particularly the larger apartment houses.

Third. Irrespective of the past or future jurisdiction of plumbing ordinances, this condition constitutes such a distinct and dangerous hazard to public health that its control necessarily becomes a subject of grave importance to health departments, as well as water departments, and a responsibility which they cannot escape or delegate.

(Presented before the Missouri Valley Section meeting, November 7, 1935.)

BACK-SIPHONING AND CROSS CONNECTIONS

By G. E. Arnold

(*Water Purification Engineer, Water Department, San Francisco, Calif.*)

The danger of contaminating a potable public water supply through unprotected cross-connections has been rather forcibly brought to the attention of the public and particularly to water works and public health officials during the last two years. The outbreak of amebic dysentery in Chicago during the summer of 1933 focused attention on this danger. The importance of this subject has been recognized for a number of years, but little has been done to correct the situation until the last decade.

This subject has been previously discussed at water works meetings by Mr. J. B. Connolly of Chicago and Mr. S. B. Morris, formerly of Pasadena.

This paper will outline the program followed in eliminating cross-connections in the San Francisco system and give the results of some special studies of back-siphoning through plumbing fixtures.

Within San Francisco there are numerous sources of water supply derived from wells, springs and creeks, as well as a number of salt water supplies. Most of these secondary supplies are used by commercial or industrial plants or for irrigation, there being but few for domestic use. Outside of the City the auxiliary supplies are used largely for irrigation. There are also a number of cities and towns which receive all or a part of their supply from the San Francisco System. Realizing that these secondary supplies, cross-connected to the piping of the municipal system, created a hazard, the Public Utilities Commission of San Francisco adopted a regulation governing such cross-connections. This regulation, adopted in August, 1933, provided that all cross-connections be protected against back-flow by properly installed, protective devices approved by the State Board of Health. Following the adoption of this regulation, an intensive campaign was carried on to locate and eliminate cross-connections with other sources of water supply. Return-

form postal cards were mailed to all water consumers outlining briefly the policy of the department and requesting that the return card be mailed back to the department indicating whether or not there was another source of water supply on the premises served by this department. More than 110,000 of these cards were mailed out and about 70,000 of them returned. All cards returned, indicating secondary sources of water supply, were indexed and an inspection made of the premises. About forty thousand cards were not returned by the water consumers. Of these places, not reporting, all premises located in areas where secondary sources of water supply might be available, were inspected, particular attention being paid to commercial and industrial plants. All other areas were carefully surveyed for wells. As a result of this survey 221 active cross-connections were found in the system. In all cases the consumers were directed to separate completely the piping of the two systems or to install two all bronze, rubber seated check valves, of a type approved by the State Board of Health. With a few exceptions good coöperation was obtained from consumers in making these installations. These cross-connections are examined every six months by this department and tested for leakage.

Bacteriological and partial chemical analyses were made of each of these secondary sources of water supply and the results noted on the card, consumers being informed of the results of the analyses when requested. Of the 221 water sources tested, 22 were found to be contaminated, less than 10 percent of the total. This includes a number of salt water supplies, all of which were contaminated.

While the survey was being made to locate secondary sources of water supply it was noted that the water and sewer pipes in a good many buildings and industrial plants were cross-connected. Therefore, it was decided, upon completion of the survey of other sources of water supply, to continue the survey, working toward the elimination of cross-connections between water and sewer pipes and other possible sources of contamination within the piping system. This work was not completed due to a curtailment of funds, but the work as far as it was carried indicated that about thirty percent of the buildings in downtown San Francisco had dangerous cross-connections between water and sewer pipes. In some cases sewage pumps, located in the basements of buildings, had a priming line connected to the pump in such a manner that it would be easily possible to pump sewage directly into the water piping of the build-

ing. Many buildings were equipped with siphon ejectors in basement sumps to pump drainage water into the sewers and were so arranged that a vacuum in the water piping or a pressure in the sewage piping would force sewage into the water piping system.

Many buildings equipped with fire sprinkling systems are served with a large connection for fire protection purposes. The automatic fire system in most cases was arranged to be tested through a by-pass around the alarm system, discharging directly into the sewer pipe. It is my understanding that the San Francisco Fire Department requires that the ammonia piping installed in refrigeration plants be equipped with an outlet to the sewer for drawing off gas in case of breaks in the ammonia piping. They also require that the ammonia piping be equipped with a water connection so that water may be sprayed into the ammonia pipes, the water dissolving the ammonia. In many cases these sewer, ammonia, water piping connections are close together, thus providing a direct cross-connection between water and sewer lines. Should ammonia be present in water pipes its high solubility could readily draw sewage into the water system. It is likely that at times of breaks, both water and sewer outlets would be open into the ammonia piping. Such times might readily be accompanied by a fire. This is an interesting case of conflict between the policies of the fire and water departments. Many buildings equipped with filters or water softeners were arranged in such a manner that the backwash line from the filter or softener discharged directly into the sewer pipe. A great number of plumbing fixtures were also found that had the water inlet pipes below the overflow level of the fixture. A number of pieces of hydraulicing equipment were found, arranged to utilize water pressure for washing or for a suction to remove wastes. All of these types of plumbing installations created a potential hazard to the purity of the potable public water supply.

It has been the policy of this department for a number of years to install one check valve at each service connection of one inch size or larger. This affords some degree of protection against contaminating the water in the street main, but check valves cannot be relied upon to function at all times and this, of course, provides no protection against contamination beyond the meter.

On a number of occasions actual contamination of the water supply has been traced to cross-connections. No doubt, there have been many such occurrences which have not been detected or re-

ported. Following are a few such cases which have come to our attention:

EXAMPLES

One case of interest occurring in San Francisco in recent years illustrates what might readily happen to a building water supply. In this case a thirteen story office building in downtown San Francisco was supplied through a single service connection with the street main. The water was passed through a sand and gravel filter in the basement of the building and was lifted by pumps to roof tanks, being spilled over the top of the tank. The tanks were covered and provided with manholes for entrance. The building was supplied by gravity from these roof tanks. The Health Department was called in to investigate an outbreak of dysentery among employees in the building. The filters located in the basement of the building were arranged to be backwashed into a sump, which also received some sewage from the building, the discharge line from the filters dropping into the sump about six inches below the rim. The water from this sump was pumped into the street sewer, the pump being operated by a float-switch in the sump and arranged to keep the sewage below the backwash line from the filters. It was found, however, that upon flushing a large number of toilets in the building at the same time, the sump would fill up to the top, the pumps not being of sufficient capacity to carry away the water. The day before this outbreak occurred there had been a fire in the neighborhood and several fire engines had been connected to fire-hydrants within a block of this building. These fire engines probably created a vacuum in the water lines, and from the building engineer's record book it was found he had been backwashing the filters at the time the fire occurred. Apparently low pressure in the water system or possible vacuum created by the fire engines had siphoned sewage from the sump back into the water filter and this matter was then pumped to the roof tanks and into the piping of the building. Bacteriological analyses indicated that the water coming from the street main was entirely free of contamination, but that all the water in the piping of the building and the water then in the filters was highly contaminated. It was found in making the investigation that a slight vacuum in the water service while backwashing the filters would siphon sewage from the sump into the filters. Two hundred and thirty employees in the building were made sufficiently

sick to require the services of a doctor at the time of the outbreak. Fortunately no typhoid cases developed, and all the employees recovered within a few days.

Another case of recent occurrence in San Francisco happened at a water front industrial plant. In this case a large pump is used to pump salt water from the bay for fire protection and for washing around the plant. This pump, having a vertical discharge, is primed, through a cross-connection with the public water supply, directly into the discharge line of the pump. The salt water pump has a discharge pressure of 110 pounds, while the main pressure at this point is only 40 pounds. The operator primed the pump with fresh water and started the pump, failing to close the valve on the fresh water line. Salt water was pumped back into the street main for some time before it was reported by a consumer living three blocks back from the water front. The water department flushed out the mains in the neighborhood through fire hydrants and afterward sterilized the mains by chlorination with a portable chlorinating unit. A sewer empties into the bay at a point near the industrial plant and the bay water here is contaminated. Bacteriological samples obtained from the street mains after flushing showed some evidence of contamination, but after chlorinating the mains all samples showed no contamination. Fortunately no cases of sickness developed from this occurrence.

Another case in San Francisco involves a public building constructed by the City and completed about two years ago. This building, used for large public gatherings, such as theatrical productions, musicals and conventions, is equipped with about one hundred water flushed toilets. The piping in the building is of adequate size to take care of the demands of the fixtures in the building, but the service connection with the street main is through a single 2-inch meter obviously inadequate to supply the demands of the fixtures. During intermissions, when there is a heavy draught on the water supply, flushometer toilets do not have sufficient water pressure to close the valves and the toilets run continuously until shut off by the building engineer. At such times the water pressure in the basement of the building drops from 80 down to 5 pounds, a vacuum being created on the upper floors in the building. Flushometer valves used in this building are equipped with a vacuum breaker, which, as far as is known, has operated successfully in preventing the siphoning of the water from the bowls into the water

piping, but the fixtures being still new are in good working order. What will happen when they become old and out of adjustment is difficult to say. Water for all of the drinking fountains in the building is taken off the main service in the basement, passed through a cooling unit and circulated through the building in a separate piping system.

Water for boiler purposes and for drinking is passed through a sand and gravel filter. The backwash line from this filter discharges directly into a sewer with only a hand valve in the backwash line. There is also a large steel tank in the basement of the building for water storage, which is kept full of water for use in emergencies, should it be necessary to shut off the street service. Passing directly over this tank is one of the main sewer outlets for the building. At the present time this sewer line is tight, but a slight leak in the sewer could readily drop contamination into the water storage tank. So far as is known no contamination of the drinking water supply in this building has occurred, but contamination of this supply would be easily possible from the poor layout of the plumbing.

The Society for the Prevention of Cruelty to Animals maintains a number of water troughs for horses on downtown streets of San Francisco. These watering troughs are supplied by this Department with water, free of charge, but the water is fed into the troughs through a connection in the bottom of the trough, the flow being regulated by a float. The water in these troughs is somewhat contaminated from street dirt.

This Department is troubled frequently by hot water backing into street mains through service connections with laundries and other plants where hot water is used. In most cases this warps the disk in the meter and the consumer is required to pay for the damage done to the meter. This, of course, is not a serious contamination hazard, as the water in most cases comes from the San Francisco system and being heated is not apt to be contaminated.

Many people are skeptical about the probability of a vacuum being created in water supply lines. The tests reported by Mr. Morris three years ago pointed out how easily such a vacuum might be created and the length of time it might be maintained. He reports that a high vacuum may be maintained for several minutes in a street main and that a relatively low vacuum may be maintained for an hour or longer. San Francisco being a hilly city is subject to wide variations in service pressure within a few blocks

and on a number of occasions vacuum in the water service has been observed on top of hills when there was a heavy draught on the water at a lower elevation. This is particularly noticeable on Telegraph Hill. Repairs and new connections to street mains often necessitate the draining of mains. Fires and other heavy draughts on water lines frequently create a vacuum.

Many of the buildings inspected during the survey were found to contain a maze of piping for water, sewer, heating and lighting conduits. In many cases the occupants of the buildings or the building engineer had little knowledge of this piping layout. In some cases the buildings had changed hands and the new owners or tenants had not bothered to find out what the plumbing plan was. Thus it is felt that many cross-connections are not known and may not be found until they cause some trouble. Of all the water consumers in San Francisco, the U. S. Government has been the most delinquent in complying with cross-connection regulations in its own buildings. In practically all cases the building engineer or the local man in charge of the building was willing to coöperate in the installation of check valves, but could not do so without authorization from Washington. Letters addressed to proper authorities in Washington have not been answered and at the present time the only unprotected cross connections that we know of in the City are those in government buildings. It is of interest to note that the cross-connection regulations were originally issued by the Federal Government and they are the ones particularly interested in cross-connections with supplies serving inter-state traffic and yet their own buildings are the ones which fail to comply with the regulations. Apparently, it takes an act of Congress for a post office to install two check valves in its water service.

A number of flushometer valves for toilets are on the market which claim to be effective in breaking a vacuum, thus preventing the siphoning of bowl contents into the water lines. A number of these have been tested and have been found to be effective in preventing siphoning, but the mechanical structure of these valves is quite complicated and they depend for their action upon a number of small openings and ball checks. When new, these valves may be quite effective, but upon becoming clogged with sediment or worn from use, they may easily get out of adjustment and fail to function.

The emphasis in this matter of cross-connections in general has been largely directed at secondary sources of water supply, little

attention having been paid to cross-connections with sewers or other building plumbing, largely due to the regulations of the U. S. Public Health Service. It is my opinion that this emphasis has been misdirected and we should more actively focus our attention on plumbing and plumbing fixtures. Most of the cases of water borne typhoid fever occurring in recent years have been caused by cross-connections, many of which were through faulty plumbing rather than with other sources of water supply. It is of interest to note that less than ten percent of the secondary sources of water supply examined in San Francisco were found to be contaminated and that only 221 such sources were found among 110,000 service connections, while the survey as far as it was carried, indicated that 30 percent of the buildings in downtown San Francisco had dangerous cross-connections within the building piping. It is felt that this Association should actively engage itself in an effort to better the present situation through education of water works people and the public in general, and in the revision of plumbing codes. Much can be done along this line and this Association could render no better service to all water consumers than aiding in the elimination of this source of disease.

(Presented before the California Section meeting, October 24, 1935.)

PROPER WATER SUPPLY AND DRAINAGE PIPING FOR HOTELS

By F. H. Waring

(*Chief Engineer, State Department of Health, Columbus, O.*)

The problem of proper water supply and drainage piping in a hotel is of vital interest to every water works official and those charged with the responsibility for safeguarding the public health. If the full truth were known, this problem would also be of vital interest to every person who has occasion to stop at a hotel.

In recent years this problem has forced itself upon the attention of public officials and the general public by reason of occurrences of water borne epidemics traceable to faulty water supply and drainage piping in so-called first class hotels. In August, 1927, Mr. William C. Groeniger, consulting sanitary engineer of Columbus and former chief of the Bureau of Plumbing Inspection, Ohio Department of Health, read a paper before the annual meeting of the American Society of Sanitary Engineering in which were cited the results of the work of a research committee of that Society and pointing out the possibilities of outbreak of water borne diseases through faulty plumbing fixtures (1). The prediction was made by Mr. Groeniger that unless those officials charged with the responsibility for manufacture, installation and maintenance of water supply and drainage piping in modern public buildings should give more attention to the proper arrangement of such piping, serious outbreaks of water borne diseases would result. His predictions have been borne out by experiences, notably in Chicago. In a discussion before the American Society of Sanitary Engineering in August, 1928, at Milwaukee, Mr. Joel I. Connolly, Chief of the Bureau of Sanitary Engineering, Chicago Board of Health, brought out forcibly the evil results arising from the carelessness in water supply and drainage piping arrangements in hospitals (2). In 1930 a paper was read before this Association by Mr. Connolly upon the subject of cross-connections in buildings. In June, 1934, Dr. Herman N. Bundesen, President of the Chicago Board of Health, read a paper before the Annual Conference of the State and Provincial Health Authorities

of North America, describing the details of an epidemic of dysentery that occurred at a Chicago hotel and in which the disturbance is traced directly to improper water supply and drainage piping of a prominent hotel (3). Additional details of the epidemic have since been given by Messrs. Bundesen and Connolly, all of which forcibly indicate to water works officials and public health authorities that the time has arrived for a careful study and checking of water supply and drainage piping for public buildings such as hotels and hospitals (4).

HOTEL CERTIFICATE REQUIRED BY A. W. W. A.

The American Water Works Association went on record in an action of its board of directors during the summer of 1934 "that the hotel where an American Water Works Association annual convention is to be held be required to submit a certified plan of their water supply and drainage piping and a certificate from the State Board of Health in which the city is situated that there are no dangerous unsanitary conditions existing." Similar actions have been taken by other associations such as the American Society of Civil Engineers, the American Public Health Association, the American Society of Sanitary Engineering, the Conference of State and Provincial Health Authorities, etc. It is entirely probable that every association of prominence holding conventions will insist that the hotel managements of the convention headquarters be required to comply with similar requirements and show evidence thereof by furnishing a certificate from state and city health authorities and water works officials.

Upon receipt by me of the official communications from President Jordan in July and Secretary Little in August, 1934, a conference was arranged at Cincinnati between representatives of the state and city health departments and the city water works officials at the office of the city manager. Pursuant to these conferences, preliminary inspections were made of the water supply and drainage piping of the Netherland Plaza Hotel with a view to complying with the Association's requirements. Fortunately, this hotel is a new one and is located in a city where plumbing inspection under the city health department was exercised by way of review of the plans before the installation was made, inspection of the progress of installation and a final inspection after completion of the work. It is, therefore, likely that many details of piping arrangements were

satisfactorily arranged before construction. The final inspection of the plumbing of this hotel, in compliance with the Association's requirements, was made on February 6, 1935 by the writer in company with A. S. Hibbs, superintendent of water works, R. W. Oliphant, chief plumbing inspector, City of Cincinnati, and Mr. Joel I. Connolly, chief of Bureau of Sanitary Engineering, Chicago Board of Health. Mr. Connolly kindly consented to assist the writer in the final inspection in order that benefit could be had of Mr. Connolly's wide experience in this field of endeavor. The final certificate was furnished to the Association on March 30th.

OBSERVATIONS GENERAL TO THE PROBLEM

The investigation of the water supply and drainage piping of a modern hotel building with a view to furnishing a certificate is not an easy one. This is especially true for those who have not been actively doing such work over a period of years and who must become familiar with the internal arrangements of piping and drainage in such a large building. To the uninitiated in this work it might be best if the first investigation work done be centered upon a modern hotel of recent construction such as the Netherland Plaza Hotel, where the piping is as originally installed, where complete detail plans are available for all of the arrangements, where a single source of water supply exists, and where reasonable precautions were taken by the architects and designers to have first class water supply and drainage piping. The reason for this is that over a period of years frequent changes and alterations will likely be made in the piping arrangements, in keeping with the additional demands that come on a plant of this character.

My own first effort was confined to two hotels in Columbus, one of which is about seventeen years old and yet still considered modern, and the other about four years old. As may be expected, there were no plans to be had of the piping arrangements in the older hotel although such plans were available at the new one. Fortunately, the engineer in charge of the older hotel had been on the job from the very beginning and was able to point out to me many of the changes that had been made over the course of years. One of the most important observations that will be noted by any who deal with this problem is that the responsibility and supervision of changes in hotel piping arrangements should be vested in a master plumber or sanitary engineer thoroughly versed in the knowledge of what constitutes safe water supply and drainage piping.

Since my own observations are confined to the investigations of three hotels in this state, necessarily my remarks must be general. At this point let me say that I was most fortunate in having the assistance of Mr. Connolly in guiding me on these three investigations. As you know, Mr. Connolly has had the experience of investigating many public buildings, hotels, hospitals, office buildings, etc. and the benefit of the knowledge that he has acquired was invaluable to me in understanding some of the situations encountered.

FEATURES OF PRIMARY IMPORTANCE FOR INVESTIGATION

I shall attempt to summarize briefly the features of hotel piping arrangements that stand out to me as being of primary importance in determining if a hotel has reasonably safeguarded its people.

1. *Cross-connections between city and auxiliary water supplies.* The first item that occurs to most of us is the question—does the hotel use any source of water supply other than the city water supply? If so, the tracing of the water supply piping has to be conducted very carefully to see that there are no direct connections between the two systems. Although it was found that the Netherland Plaza Hotel used only the city water supply for all purposes, I noted at the two Columbus hotels that well water was available to assist in refrigeration or cooling and also for air conditioning. It is likely that many modern buildings will be equipped with auxiliary water supplies from wells to accommodate the modern demand for air conditioning. Water works superintendents, therefore, will have cause to insist upon no physical direct connections between the city water service to the hotel and the well water system used for air conditioning. In the Columbus hotels which I investigated it was fortunate perhaps for me that the well water used for air conditioning was highly charged with sulphur and thus vigilance was exercised by the hotel chief engineer that there be no possible way of contaminating the drinking water supply with the sulphur water from the well. The arrangement at the Columbus hotels in question, in order to permit the sulphur water to be used for air conditioning, was a swivel joint arrangement serving the air conditioning, which meant that either city water or well water could be used but not both at the same time. In other words, a physical disconnection was made from the city service line to the air conditioner when the well water was desired to be used.

2. *House tanks and reservoirs.* It is common practice in hotels for

house pumps to be located in the basement for boosting pressure and for recirculation of water; likewise, pumps will be located on upper floors for again raising the water to the uppermost floors that are unable to be served by direct city pressure. Naturally these pumps take suction from tanks and, in turn, discharge to surge tanks or reservoirs on the upper floors. These tanks most certainly must be tightly covered and waterproof, in order to prevent contamination of the supply being recirculated. Again, there should be no drainage piping or, in fact, any piping crossing above the tank which might drip upon the roof of the tank. It will be found rather commonly that these tanks are not properly covered, if covered at all, and that precaution has not been exercised against routing the piping above the tanks. It is easy to imagine the trouble that would start if a ceiling pipe crossing above the water supply tank to the house pump should be a sewer and said sewer should be in a leaky condition; likewise, a leak of a sewer somewhere else in the building might cause drainage to follow a vent pipe or water pipe and drip onto the water supply tank if such pipe eventually crossed the supply tank of the house pump. The mere fact that a pipe crossing over a house tank is tight today is no assurance that leakage will not develop tomorrow. The safest arrangement is to have no piping extend over the house tanks.

3. *Make-up water and drain connections for recirculating systems.* Recirculation of ice water in the drinking water lines involves a make-up of drinking water and the arrangements for said make-up need to be scrutinized very carefully. Likewise, in the cooling devices and air conditioning, make-up water is needed from time to time. In both of the foregoing, it is common practice to provide for the draining of the systems. For example, air conditioning is not practiced throughout the winter period in most instances and the system is, therefore, drained and left idle; or perhaps the ice water system is taken out of service for repairs and drained. Piping arrangements whereby these systems may be drained should be carefully investigated. No direct connection, however, should be permitted between a water supply piping arrangement such as above mentioned and a sewer or drain. Wherever it is necessary to provide drains to water supply piping, surge tanks, cooling systems, softeners and filters, such connections can be through open top funnels or funnel fittings which cannot permit a back pressure upon the water supply thus connected. Furthermore, the make-up water to pans under the air

washers should be by means of an over-the-rim connection controlled by ball float or other suitable device, the inlet water supply pipe to be above the overflow of the pan.

4. *Sewage pump priming connections.* Sewage and drainage from floors above the street level are conducted from the hotel to the street sewer ordinarily through direct connections; but for the floors below the street level the sewage is lifted from sumps located in the basements or sub-basements by means of sewage pumps or ejectors which discharge the sewage through a force main into the street sewer. It is important that these sewage pumps be free from direct water priming connections, for obvious reasons. The pumps should be primed by means of water conducted from a small tank, the supply to which is fed over-the-rim of the tank above the overflow line.

5. *Laundry trays and dishwashing machines* are commonly afforded with bottom water inlets in the older style of washing devices. Obviously, the water inlets might better be at the top of the device; or the water supply piping may be equipped with vacuum breakers or checks to prevent back siphonage.

6. *Soda fountains, bars and grills* are equipped with wash tanks for the glasses and utensils. Here again bottom inlets for the water offer the possibility of back siphonage which may be avoided by properly equipping the piping with vacuum breakers and checks. In both of the above mentioned instances vigilance must again be exercised to prevent the direct connection of the rinse water supply into the drain or sewer.

7. *Plumbing fixtures in guest rooms.* After the survey of piping arrangements in the basements or intermediate floors, where house pumps, air conditioners, etc. may be located, attention is now directed to the possibilities for poor piping arrangements in the facilities of the guest rooms. The three types of fixtures which immediately come to mind are the toilets, lavatories and bath connections. The bath and lavatory arrangements are similar; the fool-proof arrangement against possible contamination of the water lines by back siphonage is the provision of over-the-rim water inlets in which case the flooding elevation is somewhat below the water inlet elevation. Submerged inlets to lavatories, tubs and toilets naturally make possible a gravity drainage of the contents into the water supply piping whenever a vacuum or partial vacuum occurs in the water supply piping and leakage exists at a faucet or valve.

At this point I wish to call attention to the extreme likelihood, and

not the extreme improbability, of partial vacuums in water lines. Water distributing piping in a modern building is not designed 100 percent perfect hydraulically, so that a sudden demand for water from many fixtures on the lower floors may exhaust the pressure in the water lines of the upper floors although this exhaustion of pressure may be only momentary. It is, therefore, important that the fixtures in each room be as fool-proof as possible against back siphonage.

Common practice today is toward the use of flush valves for toilets; and such flush valves will usually open under vacuum or partial vacuum. Therefore if the flush valve connection to the toilet is from the side there is a gravity submergence of this valve which permits a back siphonage readily into the water supply piping if said water pressure fails. Obviously, the top entrance from the flush valve is safer, although not fool-proof necessarily; stoppage of the toilet outlet and subsequent flooding up to the rim of the bowl is needed for some types of toilets for a back siphonage to occur through a top inlet flush connection. Flooding is not necessary in some siphon jet toilets. All flush valves should have equipment on the discharge side for vacuum breakers, with an additional protecting device consisting of a partial check valve in the line on the opposite side of the flush valve. This partial check valve holds the vacuum only to that point which will permit air to enter through the ports of the vacuum breaker. Toilet flush valves should always be located at a higher elevation than the top of the rim of the toilet to minimize the chances of back siphonage. In cases where flush valves have been installed with no vacuum breakers or checks, and where such installations subsequently would be difficult, it is possible to give some measure of protection by installing the vacuum breakers upon the ends of the risers of the water supply piping serving these fixtures.

8. *Drinking fountains* should be of the type with the projector located above the rim of the fountain bowl. Obviously, if the projector is below the rim, submergence can take place when there is a stoppage of the drain pipe and siphonage might ensue in case of loss of pressure in the supply line. These features of drinking fountain design are separate and apart from other sanitary features; naturally the projector should be guarded so that the mouth cannot be placed over the projector. This may be accomplished by having a proper angle of projection of the stream of water from beneath a suitable guard.

CONCLUSIONS

In the foregoing discussion the attempt has been made to hit the high spots of water supply and drainage piping investigation of a modern hotel. Many details, of course, will come up and time will not permit of presenting all of these features. One bit of advice can be given to hotel managements which will simplify investigation and help the management itself to guard against possible trouble. If the water supply piping is given a distinctive paint, such as light blue (recommended by the Chicago Board of Health), and the other piping given equally distinctive coloring such as green for steam piping, black for drainage piping, and red for auxiliary water supply piping, or some such color scheme, the investigations and proper maintenance of the piping arrangements will be facilitated. It would pay any hotel to go to the trouble of tracing out its piping by means of a color painting scheme.

A corollary of this thought is that no changes in piping should be made except with the knowledge and consent of the chief engineer of the hotel or other individual charged with the responsibility of the arrangements, and except with the knowledge and consent of the city health department plumbing inspector. It would pay a hotel to have in its employ, either on a part time or full time basis, a capable sanitary engineer trained in this phase of public health protection. This point was emphasized by Mr. Wolman at last year's meeting in his discussion of the papers on amebic dysentery by Messrs. Connolly and Gorman. The supervision and control of this sort of inspection on the part of the municipality should by all means be vested in the local department of health and not the building inspection department.

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(4) Plumbing and Public Health, Dr. Herman N. Bundesen. Presented at the Annual Convention of the Ohio State Master Plumbers Association, Columbus, Ohio, February 5, 1935.

(5) Cross Connections in Plumbing and Water Supply Systems, A. A. Kalinske and W. S. Kinne, Jr., Prof. F. M. Dawson and Mr. Frank R. King. Published jointly by University of Wisconsin and Wisconsin State Board of Health, February, 1935.

(Presented before the Cincinnati Convention, May 7, 1935.)

REPORT OF COMMITTEE ON CONVENTION HOTEL SANITATION[1]

To the Board of Directors—American Water Works Association:

1. Your committee on "Convention Hotel Sanitation" was charged with the duty of clarifying the expression of intent on the part of this board and laying down a line of procedure which should be followed in order to assure satisfactory sanitary conditions in hotels where the organization holds its annual conventions.

2. A review of the background of the resolution passed by this board is desirable.

While sanitary engineers generally (including many members of this Association) have for several years understood that hazards to health existed in factories, office buildings, hotels, etc., because of lack of intelligent control of maintenance of internal water and sewage piping, neither the magnitude of the problem nor the intensity of the danger was appreciated until the outburst of amoebic dysentery in Chicago in 1933. The epidemiology of this outburst and the studies of hotel sanitation made since in Chicago and elsewhere show that the peak loads placed upon services during large conventions serve to intensify the dangers present. They also fully justify an association such as this in any regulation it may set forth which tends to protect the health of its members and guests at a convention.

3. Records of this board show that, on June 7, 1934 the following motions were adopted:

(1) "The recommendation of the committee on water works practice be adopted that the hotel where an A. W. W. A. annual convention is to be held be required to submit a certified plan of their water supply and drain piping and a certificate from the State Board of Health in which the city is situated that there are no dangerous unsanitary conditions existing."

[1] Approved by the Board of Directors, January 16, 1936, New York City.

(2) "Secretary Little, on behalf of the convention committee, be instructed to make a written report to the board on the sanitary condition of the convention hotel to be presented at the time of the recommendation of the convention committee on choice of city and hotel."

4. The 1935 convention hotel was the first one subjected to the conditions above set forth. It was found impractical for our Secretary to obtain and study a "certified plan of their water supply and drain piping." Inasmuch as full coöperation was obtained from the State Sanitary Engineer of Ohio and since this coöperation included not alone a study of the original piping plans but several inspections of the hotel property, it is considered that the information underlying the certification was adequate. Certain changes were recommended to the hotel management; the changes were made; and, on March 30, 1935, the approval certificate was issued by F. H. Waring. As a matter of record, a copy of that statement is attached to this report.

5. The experiences leading up to the filing of Mr. Waring's certificate indicate that the precise phraseology of the second motion adopted on June 7, 1934 cannot be practically followed, nor is it certain that certification so far in advance of a convention is desirable. It appears more logical to (1) advise members of the Association generally, as well as hotel managers who are interested in obtaining a convention of the Association, concerning the necessity of certification prior to the holding of a convention; (2) furnish them with a list of "hotel health hazards" which must be corrected, if they exist; (3) obtain from the hotel manager a letter to this board agreeing to comply with such orders as a State or Provincial Sanitary Engineer may issue looking toward elimination of hazardous conditions; (4) obtain from the State or Provincial Sanitary Engineer (*a*) a preliminary statement to the effect that, in the hotel in question, no sanitary hazards exist that cannot be eliminated with a reasonable expenditure of money, and (*b*) an agreement upon the part of the Engineer to make a fully adequate survey of the hotel at least nine months in advance of the convention date; such survey to be followed by (*c*) orders for elimination of hazards if found, by (*d*) a check survey five months before the convention date and (*e*) a certificate of compliance at least three months before the convention date.

6. Since this is an association of persons interested in the development and operation of public water supply, and further since it is

recognized that private supplies in hotels, etc. are seldom protected and tested with the degree of care given to the public water supply[2] it appears proper to give preference, in the selection of convention headquarters, to that hotel which uses the public supply over the one, if any, which does not.

7. Since this Association is in full accord with movements looking toward the highest degree of safety in public water supplies, and since the quality standards set for interstate carrier waters are within the practical limits of water works operation, it appears proper for this Association to decline to hold its annual convention in any city the public water supply of which does not conform to the U. S. Treasury Standard of drinking water for interstate carriers or its equivalent in the Dominion of Canada.

8. Your committee therefore presents for your consideration and adoption the following statement of policy and outline of procedure relative to the sanitation of convention hotels.

I Annual conventions of the American Water Works Association will be held only in hotels where the internal water and sewerage system has been inspected by the State (or Provincial) Sanitary Engineer; where defects, if found have been fully and adequately corrected; and further where a certificate evidencing the lack of and/or corrections of sanitary hazards has been furnished to the Secretary of this Association by the State Sanitary Engineer.

I-A In order to carry out these provisions the Secretary of this Association shall:

1. Provide a circular of information concerning these requirements for the use of all persons who may be interested in obtaining a convention of this Association for their city or hotel.
2. Require, before action is taken by the convention place committee, that the manager of any hotel under consideration furnish, in writing, a statement agreeing to comply with such orders as the State or Provincial Sanitary Engineer shall issue relative to the elimination of sanitary hazards in such hotel.

[2] Clause in paragraph 6 "and further since it is recognized that private supplies compete destructively with public supplies," deleted at the request of Mr. Brush.

3. Require from the State or Provincial Sanitary Engineer:
   (a) A careful sanitary survey of the hotel not less than 9 months prior to the convention date.
   (b) A check survey not less than 5 months prior to the convention date, at which time progress in compliance with previous orders shall be noted.
   (c) A final survey and certificate recording satisfactory conditions not less than 3 months prior to the convention date.

   If the hotel in question has been similarly surveyed within the year previous and conditions corrected that time, the preliminary survey (a) may be omitted. If survey (a) indicates satisfactory conditions, survey (b) may be omitted. In any case the final survey (c) and certificate must be furnished the Secretary of the Association at least 3 months prior to the convention date.[3]

   The Secretary shall require a written record of each survey above listed, and is authorized and required, in case satisfactory progress is not being made, to consult with the executive committee of the Association to the end that a transfer of the convention site to another location be authorized.

II Other conditions being equal, preference shall be given to a hotel which uses the public water supply over a hotel which has provided itself with a private water supply.

II-A The data incidental to the above may be obtained from the Sanitary Engineer as items in the survey of the hotel.

III Conventions of this Association will not be held in cities whose public water supply is not certified as meeting the requirements of the U. S. Public Health Service standard for water for use on interstate carriers or their equivalent in the Dominion of Canada.

III-A The Secretary shall file with this board at each annual meeting, a list of the cities of over 100,000 population in Canada and the United States, whose public water supply is not certified for use on interstate carriers, which record will serve to indicate the availability of any city as a place for a convention under the terms of Section III.

[3] Note: First paragraph after 3 (c) inserted as result of correspondence with F. H. Waring.

IV The regulations hereinabove set forth shall govern, so far as is now possible, the 1936 convention of this Association, and shall fully govern procedure relating to sanitation of the 1937 and subsequent convention hotels.

9. This report is submitted for your consideration and adoption.

Respectfully submitted

Committee on Hotel Sanitation,
W. W. BRUSH
L. H. ENSLOW
ABEL WOLMAN
H. E. JORDAN, *Chairman.*

APPENDIX

[COPY]

DEPARTMENT OF HEALTH
Columbus, Ohio

March 30, 1935

Subject: Cincinnati Water Supply

Mr. B. C. Little, Secretary,
American Water Works Association,
29 W. 39th St.,
New York City.

Dear Mr. Little:

Pursuant to the request of the American Water Works Association forwarded by you to me under date of August 10, 1934 and pursuant to action of the board of directors of the American Water Works Association, I now report to you relative to the sanitary condition of the water supply and drain piping of the Netherland Plaza Hotel, Cincinnati, which place was duly selected by the association as the meeting place of its 1935 convention in May.

Original inspections of the hotel piping were made by the authorities of the city of Cincinnati following your communication of last August and following a conference by me with the authorities in August, 1934. Mr. A. S. Hibbs, water works superintendent, Mr. J. S. Shuey, chief sanitary inspector, Cincinnati Board of Health, and Mr. R. W. Oliphant, Bureau of Plumbing, City of Cincinnati, made the preliminary inspections and reports. I personally made examination of the hotel piping arrangements on February 6, 1935, accompanied by Messrs. Hibbs and Oliphant, city of Cincinnati, and Mr. J. I. Connolly, Chicago Board of Health, who at my request assisted in the examination of the equipment. I now have before me the final report of Messrs. Oliphant and Hibbs stating that the recommendations given at the final inspections on February 6th have been carried out and, therefore, I am

in position to advise you that the Netherland Plaza has complied fully with the recommendations to them from the local and state departments of health, and that there are now no dangerous unsanitary conditions existing in this hotel to our knowledge. In other words, the hotel management has complied with all regulations and requirements re internal piping connections as set forth to them by the local and state departments of health.

I trust that this statement is what you desire and if there are any omissions or corrections, please let me know.

Yours truly,
(Signed) F. H. Waring,
Chief Engineer.

CC Mr. A. S. Hibbs,
Cincinnati Bd. of Health
Royal Ryan, Mgr.,
Netherland Plaza Hotel, Cincinnati, O.

FLUSHING LARGE SUPPLY MAINS IN BUDAPEST, HUNGARY

By Lipót Vojcsik

(Superintendent, Distribution System, Water Works, Budapest, Hungary)

The waterworks of Budapest have their biggest plant in Káposztásmegyer, which is some 6400 feet from the boundary of the City. From this plant two 48-inch diameter mains, lying parallel on the Váci road on each side, deliver the water to the City. Outside the boundary the pipes have no branches, but from the boundary where the City begins there are many buildings and factories. Consequently the distributing pipes are connected with the main feeders.

Approximately 5 miles from the Káposztásmegyer plant one of the supply mains goes south east and the second, reduced in its diameter, travels southward to the City. The large water mains in two places are directly connected to each other by 48-inch diameter pipes: (1) before the plants, (2) on the Berlin square. At each connection a gate valve exists. Each main delivers daily 2,160,000 to 3,250,000 cubic feet water as the consumption requires.

The successful flushing of these large mains, as everywhere, was always a difficult task. Formerly the problem was solved so that from time to time (monthly) one gate valve was closed on one of the mains, so this main did not deliver water from the plant. Therefore, the necessary water for the City arrived only through the second main. If the water level of the reservoirs made it possible, the pumping was so regulated that the pumps pumped a water quantity corresponding to 5,400,000 cubic feet daily delivery. Consequently, the velocity in the working main was raised from the average 2.3 to 3.3 to about 5.6 feet per second. This increasing velocity was breaking off the deposits from the main wall, and so it was cleaned. When the water became red, as in the Berlin square and in its neighborhood, we opened 10 to 12 hydrants and so flushed out the rusty water. Naturally the rust tended towards the distribution system and the reservoirs and it was removed with the systematic flushing of the distribution system and with the washing of the reservoirs.

After the world war the situation was changed.

The pumps of the plant in Káposztásmegyer take the water from wells which are sunk in the bed on the bank lines of the Danube. During the war and after it the demand of the population and industry for water was growing. Therefore, the wells were brought into action very strongly against the water shortage. Furthermore, the Danube was regulated and in consequence of this construction a great part of the bank line became muddy and much organic material was deposited on the originally good bed. Formerly iron and manganese were not noticeable in the water, but at this time we found them in measurable quantity. Moreover, the iron and manganese bacteria, crenothrix and gallionella, appeared. The inhabitants have also complained of this trouble.

In consequence of these circumstances it became necessary to construct a filter plant for chlorination and dechlorination with

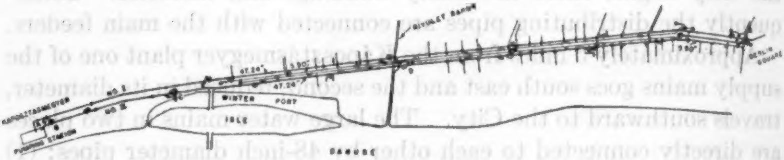

FIG. 1. PLAN OF 47.24 INCH (1200 MILLIMETERS) DIAMETER MAINS

activated carbon. But, before this filter plant could be operated, we had to provide for the reduction of the formation of deposits in the distribution system. Inter alia, we eliminated the dead ends and joined them in the gridiron system. In addition, however, it was necessary to find a method for more effective flushing of the supply mains.

PROCEDURE

The following procedure was successfully tried and after finishing the filterhouse construction we practice it every second or third year.

We designate the 48-inch diameter supply main which is on the town side of the Váci road as No. 1, and that lying nearer to the Danube as No. 2. The night before the flushing, we close all the valves of the branches of the main No. 2. The supply of the population is secured from the gridiron system. Otherwise we flush the mains when the consumption is not high, on Sundays in spring or

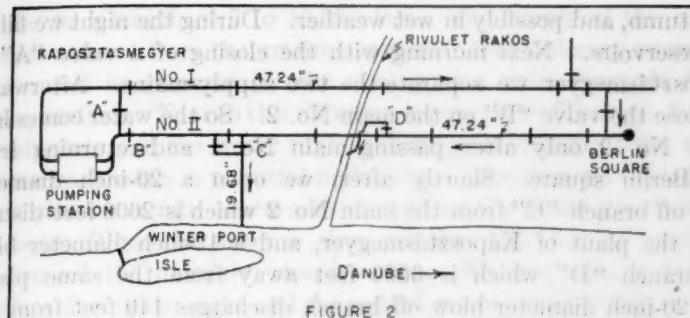

FIGURE 2
SKETCH OF THE SCHEME OF FLUSHING THE 47.24" DIAMETER MAINS

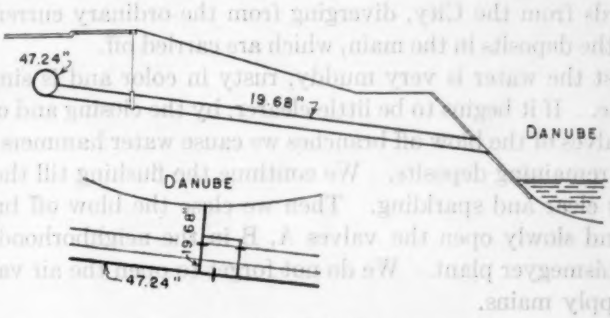

FIGURE 3
PLAN OF THE BLOW-OFF BRANCH "C"

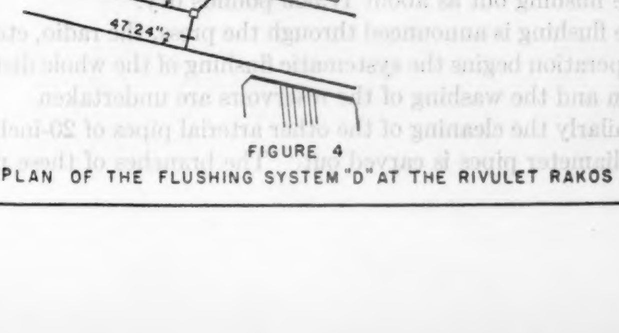

FIGURE 4
PLAN OF THE FLUSHING SYSTEM "D" AT THE RIVULET RAKOS

in autumn, and possibly in wet weather. During the night we fill all the reservoirs. Next morning with the closing of a valve "A" in Káposztásmegyer we separate the two supply-mains. Afterwards we close the valve "B" on the main No. 2. So the water comes into main No. 2 only after passing main No. 1 and returning from the Berlin square. Shortly after, we open a 20-inch diameter blow off branch "C" from the main No. 2 which is 2600 feet distant from the plant of Káposztásmegyer, and a 12-inch diameter blow off branch "D" which is 6600 feet away from the same plant. The 20-inch diameter blow off branch discharges 140 feet from the main to the basin of the port of the Danube. The water from the 12-inch diameter blow off branch discharges 150 feet away from the main. It runs first in a shaft, and from here it discharges through a 130 feet long pipe line to the Rákos river. Now the water is flowing backwards from the City, diverging from the ordinary current, and stirs up the deposits in the main, which are carried off.

At first the water is very muddy, rusty in color and is similar to chocolate. If it begins to be little clearer, by the closing and opening of the valves of the blow off branches we cause water hammers, which free the remaining deposits. We continue the flushing till the water becomes clear and sparkling. Then we close the blow off branches C, D, and slowly open the valves A, B in the neighborhood of the Káposztásmegyer plant. We do not forget to open the air valves on both supply mains.

The water, now flowing in the ordinary direction, should not convey any rust to the city. We allow 8 to 10 hydrants to run on the Berlin square and flush them, till the water is perfectly clear. Naturally with this method, during the flushing of the supply main, No. 1 will be also cleaned, because during the whole operation water is flowing only through this main towards the city, so that the great velocity, over 6.5 feet per second, tears up the deposits in this main.

This method lasts 12 to 18 hours. An average of 2,150,000 cubic feet water is used for that purpose and discharged into the Danube or the Rákos. We can estimate the manganese and iron rust which we are flushing out as about 17,500 pounds dry.

The flushing is announced through the press, the radio, etc. After this operation begins the systematic flushing of the whole distribution system and the washing of the reservoirs are undertaken.

Similarly the cleaning of the other arterial pipes of 20-inch and 24-inch diameter pipes is carved out. The branches of these pipes will

be closed in a length of 7 to 10,000 feet. The supply of the consumers is assured from the gridiron system. The ordinary current direction will be changed by the closing of a valve towards the pumping station. Near to this valve we open a blow off branch, 6- to 8-inch diameter, so the water running with great velocity from the reservoirs backwards is powerful in flushing. The blow off branches conduct the water into shafts and from these the water pours into the sewers. When the water is clear, we close the blow off branch and open all the formerly closed valves. We are making these operations during the night and the water becomes clear within some hours.

READING AND SERVICING METERS

By Eugene Schwarz

(*Superintendent Water Department, Rochester, Minn.*)

Meters are purchased in Rochester under a blanket contract in January of each year. This contract covers a hundred meters or a fraction thereof, with a guarantee against any advance in price and the benefit of any reduction in price during the term of the contract. Some 13 years ago, the Board of Public Utilities, then in office, ordered a change in the type of meters to be purchased, when the contract was to be renewed. The Mayor and some of the Aldermen objected, stating that the contract was in-valid and ordered the Board to advertise for bids, which meant that we had to purchase a cheaper meter, made for competitive purposes and which the majority of the Board did not want. Upon my suggestion the Board by unanimous vote passed a resolution to purchase now and in the future the type of meter of which the City of Rochester had a majority of meters installed and of reputable make. It has nearly standardized our meters and eliminated the friction between the powers that be and the Board of Public Utilities having charge of the water and light departments. While the price of the meter adopted is somewhat higher, it has given us the freedom to purchase a meter best adapted to our needs, regardless of price and sales talk of other types of meters, a freedom of action that would no doubt be appreciated by many water superintendents in the selections of their meters. In fairness to the manufacturer of water meters, I wish to state that I do not in any way discredit the efficiency of their meters, as I know there are many good meters made and sold. However, I do believe that the water superintendent is best suited to select the type of water meter needed, rather than the Aldermanic Body of the City.

READING

The method used at Rochester in reading meters is somewhat different from other cities, due to the fact that all financial transactions of both the Electric Light and Water Departments are under the supervision of the Secretary of the Public Utility Board, who has

also charge of the meter readers. The city is divided into four sections and read alternately by these corps of all time meter readers, who read the electric as well as the water meters. Electric meters are read monthly, water meters in industrial plants and hotels are read monthly, while meters in residences are read quarterly. While this method of reading meters at Rochester seems to work out satisfactorily, it may be of no advantage in other cities.

It seems to be the general rule throughout the water works field to read residential meters every 3 months or quarterly. This is to reduce the cost of billing as well as meter readings and again due to the fact that these bills are comparatively small. If taken from this point alone, then why not further reduce the cost and read these meters semi-annually? And again why are electric meters read monthly regardless of the amount of the bill. From my personal observation a meter cannot be read too often. A residential meter should be read as often as a larger meter, because the service into a large percent of residences, due to the small amount of water used, acts in many ways as a dead end of a distribution main, the water due to its dormant stage for many hours out of the 24 will deposit all insoluble parts into these so called dead ends, and when the meter is called upon to register a small amount for the morning ablution the flow is not strong enough to flush out the line, but will deposit these impurities in the meter, a handy trap, which will cause the meter over a period of months or even years to become sluggish. In time it will stop altogether. During the period of sluggishness to total stoppage of the meter, much water passes through the meter without being registered, and when the meter is read quarterly the loss of revenue may be considerable before the meter is detected to run slow or is stopped, while with monthly readings you have a check on these meters every month, eliminating much dispute over estimated bills and creating a better feeling between the consumer and the water department.

SERVICING

Servicing of meters is to keep the meters in good workable condition. It is to the benefit of any water department to have the meters register within the allowable 2 percent limit. A customer knowing that his meter is taken care of by the department, will upon a receipt of a somewhat larger bill, look for leaks in his piping and fixtures, before registering a complaint to the department that his meter is

wrong. While some of these calls are "false alarms" as far as the meter is concerned, the answering of the calls is appreciated by the customer, and worth the expense.

REPAIRING

The meter repair department is of very much importance to any water department. Upon its efficiency will not only depend the cost of repairs, but also an added revenue in making repairs promptly. The efficiency of meter repairs as a whole, in smaller cities like Rochester can not be on a par with our three larger cities, where an all time repair department is maintained. The meter department in Rochester is serviced by two men, making all repairs on meters, installing new meters, servicing and testing all meters, making investigations for leaks due to high water bills, also re-reads for the same purpose, making all taps for new services, locating old curb boxes having been covered up, answering calls for turning off service lines for repairs or otherwise, and turning them back on again. This illustration is only given to compare the work of a repair department of our three larger sister cities with the meter department of our smaller cities.

All repairs to meters caused by natural wear or breakage due to wear, are made free of charge. This will include all internal parts of meters up to 2 inches. Replacing of discs and pistons caused by hot water backing into the meter, will be paid for by the consumer as well as for bottoms which have to be replaced due to freezing. All internal parts in larger size meters such as intermediates, registers, or any part thereof are replaced free of charge. With the exception of meters located in industrial plants or the larger hotels, where city water is used only intermittently or as a standby, all repairs to the meters must be paid for by the consumer.

TESTING

Testing of meters can be classed as a part of servicing meters. We test our larger size meters semi-annually, while the smaller meters, $\frac{5}{8}$- and $\frac{3}{4}$-inch, are tested only on complaint of a customer of a high water bill, or on the report of the meter reader. In testing the larger size meters we use a test meter, eliminating much labor in disconnecting the meter. The smaller size meters are brought in and tested on the testing machine. All tests are made free of charge.

OWNERSHIP

Meters in Rochester are purchased and paid for by the property owner. They must be purchased from the water department to insure the type of meter upon which this department had standardized. They are sold to the customer at wholesale price and are installed free of charge. This custom was established by the company, first owner of the water works. When the city took over the water works in 1916, the same custom was continued.

The ownership of water meters by the customer and property owner, is you will agree a financial advantage to any water department, but will not the advantages, gained by a water department through ownership of the meters, such as complete control over the meters, their size and type best suited for the service, freedom of action in servicing a meter at all times, the elimination of the ill feeling of a compulsory owner towards the water department, to furnish the measuring device upon which his water bill is based, offset the expenditure in the purchase of the water meters by the department?

(*Presented before the Minnesota Section Meeting, October 18, 1935*).

WELL PROGRAMS AT MISSOULA AND HAMILTON, MONTANA

By H. S. Thane

(*Superintendent, Missoula Division, Montana Power Company, Missoula, Mont.*)

MISSOULA

The water supply of Missoula is taken from Rattlesnake creek. The intake dam, a reinforced concrete structure, forms a reservoir of about 3 million gallons capacity located about $3\frac{1}{2}$ miles from the center of town. From the intake water is conveyed through a 30-inch continuous stave redwood pipe 17,000 feet long to a 1,000,000 gallon concrete distributing reservoir located about $\frac{1}{2}$ mile from the center of the business district. The capacity of this supply line is about 20,000,000 gallons per 24 hours, and the peak rate of demand in the summer for lawn and garden sprinkling amounts to about 18,000,000 million gallons for 24 hours. This peak rate continues for a period of two or three hours daily during the season, and the daily consumption amounts to 12,500,000 million gallons almost every day for a period of three or four months.

High water consumption

This extraordinary consumption of water, amounting to a peak rate of over 1000 gallons per capita and a daily average rate of about 750 gallons per capita is due to two factors, the nature of the subsoil, which is gravel extending practically from the grass roots, and capable of absorbing an unlimited quantity of water; and the habits which have been formed by the users over a period of many years during which an abundant supply was available for their use on flat rates, with no incentive to economy.

From an engineering standpoint, the obvious remedy is the use of meters, but this step is extremely unpopular with our customers, and, while we feel that it is likely to be an ultimate necessity, we are reluctant to inaugurate a metering program, especially during these times.

We feel also that restrictions on the use of water for sprinkling would discourage the development of lawns, trees and shrubbery, and thus tend to remove one of the main reasons for our deserved name of "Garden City."

The supply line from the intake to the distribution reservoir was built in 1902, and, while it is generally in good condition, we have found it necessary to replace some staves during the past few years. The possibility of a major break in this pipe line, which might require several hours, or perhaps some days, to repair has been pointed out by the Fire Underwriters for some time, and, while we do not believe this danger is at all imminent, it still remains a definite hazard.

In order to provide for this contingency, a program for development of wells was undertaken in the latter part of 1934, and we have at present completed three wells and propose to install a fourth.

Underground sources

Geologists inform us that the valley in which Missoula is located was originally a lake bed, and that the prospects of finding underground water of good quality and in large quantities are very good. The wells completed to date are No. 1, at Sixth and Ivy; No. 2, at 14th and Johnson; No. 3, at South Avenue and Park Street. These are all drilled wells, cased with 12½-inch oil well casing, and vary in depth from 90 to 120 feet. We have installed in them three Pomona pumps, of the turbine type, driven by direct connected, Westinghouse, 2200 volt, 100 H.P., 1800 RPM motors. A check valve is attached to the pump discharge, and beyond it, about 8 feet of 10-inch pipe to an elbow pointing down which is connected to the main, with a gate valve on the branch line. A Sparling meter is inserted in the pipe immediately following the check valve, and the starting switch, metering equipment, etc., are mounted on one wall of the 8 by 10 galvanized iron building, which is so arranged that one end can be taken out and the balance of the building moved off foundation to provide for pulling the pump if necessary. The pumps are rated at 1200 gallons per minute against a total head of 240 feet.

Incidentally, we found two unlooked for difficulties in completing these wells. The protection of the well after completion of drilling and before the pumps had been set. It appears that the ubiquitous small boys delight in dropping rocks down the well and given half

a chance will fill the casing with rocks. The second practical difficulty was experienced in disposing of the waste water at the period when the well was being developed, i.e., being pumped out.

Although No. 1 well was completed first, it was more convenient to set the pump at No. 2 well, and we therefore developed this well first. The well started with a flow of perhaps 200 gallons per minute, but gradually increased over a period of about two weeks to a flow of 1200 gallons per minute, the water being pumped to waste during this period. The development consisted of washing the clay and sand from the gravel at the foot of the well, the effect being to build up a pocket of coarse gravel at the bottom of the well, which would permit the water to enter the casing. This was done by operating the pump intermittently, perhaps five minutes on and one minute off, in order to shake the formations at the bottom and loosen the fines.

Well No. 1, on Sixth Street, was apparently drilled in an old river channel, as the formations consisted of strata perhaps 2 feet thick of clay followed by 2 to 3 feet of gravel. We had some misgivings as to the capacity of this well, and when we started to pump we found that after running for two or three days the flow dwindled from about 300 gallons per minute to nothing, and the pump could not be re-started, and it was necessary to pull the pump and wash the sand from the runners. We found that the sand had filled the runners solidly to a height of about 18 inches above them, a total of 9 feet in the drop pipe. On cleaning the pump and replacing it, the flow gradually increased to 600 gallons per minute, which appears to be the maximum for this well, as so far we have been unable to produce any more water, although it still pumps a little sand and fine gravel.

Analysis shows the total hardness of these two wells to be 167 p.p.m. As the hardness of Rattlesnake water is 24 p.p.m., the difference is noticeable. This well water compares favorably with many of the waters in the State, but our customers, being used to the very soft Rattlesnake water, objected strenuously to the hardness of the well water. The wells are justified as a standby only, as they constitute a material improvement in the fire defense facilities. However, we are at present experimenting, in the hope that we may be able to store Rattlesnake water underground during periods when the demand is low and pump from storage under peak conditions. Our thought is that possibly the soft water may stay

in the neighborhood of the wells, so that it may be pumped out without being appreciably mixed with harder water, but this, of course, depends to a large extent on whether the water in the ground is stationary or moving. We also hope to increase the production of the No. 1 well by this backwashing method, but have not proceeded far enough to have any definite results.

All three of the wells have roughly 15 feet of clay seal at a depth of between 30 and 50 feet, and the sanitary quality is high. Slight evidences of contamination have been found on first starting the wells, which disappeared shortly. The No. 2 well behaved in this manner and was dosed with hypochlorite of lime and then pumped out, the following tests being satisfactory. Apparently, this condition is due to local contamination of the casing, drill, etc. We hope to obtain a total capacity of 5,000,000 or 6,000,000 gallons per day from the four wells.

HAMILTON

Our source of supply at Hamilton has been from Skalkaho creek, through about five miles of 10-inch pipe, to the city distribution system. At the two ends of the city distribution system, about five miles of 4-inch–100 feet head, wood pipe was laid about 1910 by some real estate promoters, and was subsequently purchased by the Company. Since the static pressure in Hamilton is about 108 pounds, this system required rather careful handling to hold the pressure down to 60 pounds or less on this low head wood pipe, the balance of the system being steel and suitable for the pressure. In December, 1934, this five miles of wood pipe was replaced by 6-inch cast-iron.

Well supply

While the sanitary quality of the Skalkaho water was satisfactory after chlorination, there was a considerable aesthetic objection to this supply, due to the practice of feeding cattle along the banks adjacent to the stream. It was therefore decided to change from the surface supply to a well supply, and two wells have been completed to date, the third being in process of construction. The No. 1 well, about 67 feet deep, is equipped with a Pomona pump, Westinghouse 25 H.P., 440 volt motor, and is designed to deliver 400 gallons per minute against a total head of 180 feet. It is housed

in a galvanized building similar to that described at Missoula, and is located at the southeast corner of the city distribution system.

The No. 2 well is located about 1000 feet east of the center of town, on the 10-inch supply main, and is equipped with a Pomona pump, Westinghouse motor—50 H.P., 2300 volt, rated at 800 gallons per minute against a head of 180 feet. This well also is housed similar to No. 1. The third well is now being drilled about 700 feet east of the No. 2 well.

A 500,000 gallon, covered steel reservoir is to be installed at a point on the supply line where a suitable elevation can be obtained adjacent to the line. This will deliver 75 pounds static pressure from the full reservoir, and is intended to provide for service during outages of the transmission line which supplies the town, and incidently the pumps. The peak load is estimated at 100,000 gallons per hour during the sprinkling season, the use of water and the soil conditions being comparable to Missoula, although on a smaller scale.

As a further standby fire protection service, we plan to keep the 10-inch main from the Skalkaho supply alive and connected to the supply line at the reservoir, using two valves with a drain pipe between them to obviate any possibility of Skalkaho water entering the system, except in extreme emergencies. Our idea is that in all probability this supply will never have to be used, but it offers an additional safeguard for conflagration conditions which will probably appeal to the Underwriters.

The sanitary features of the Hamilton supply appear to be about the same as in Missoula, and the total hardness is about 140 parts per million, as compared with 115 parts per million from the Skalkaho supply, so no objection is anticipated from the consumers on account of hardness.

(Presented before the Montana Section meeting, April 13, 1935.)

LIST OF SECTION PAPERS

New York Section

New York, N. Y., December 27, 1935

Water Works Construction in New York State with Federal Aid **Earl Devendorf**

Destroying by Over-Pumping a Ground Water Supply of Approximately 100,000,000 Gallons Daily .... **Wm. W. Brush**

Air Conditioning in Relation to Water Consumption .... **L. L. Lewis**

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Tanks and Booster Stations Demonstrate Their Value. Donald H. Maxwell. Eng. News-Record, **114**: 623–4, May 2, 1935. Recent developments in introduction of elevated tanks and booster pumping stations show increasing realization of advantages of such facilities for economically correcting undue pressure fluctuations and relieving local water shortage situations. Several examples are outlined. At Glencoe, Illinois, elevated tank has reduced power consumption per million gallons delivered into mains from 1835 to 1235 kilowatt-hours, estimated annual saving of $2500 being sufficient to cover interest, depreciation (on sinking fund basis), and maintenance of tank.—*R. E. Thompson.*

Elevated Tanks in Detroit Eliminate Pressure Pulsations. George H. Fenkell. Eng. News-Record, **114**: 624–5, May 2, 1935. There are now 5 tanks in Detroit water system, 4 of 1.5-million gallons capacity and 1 of 5-million, first of which was placed in operation in 1927. As result, pulsations in pressure, inevitable in closed system, have been largely eliminated. Tanks are allowed to ride on line during spring and autumn, and also in winter provided fluctuation in level is sufficient to prevent freezing; otherwise tank is drained during coldest months. During summer, tanks are filled during night and water held until most needed (5–6 p.m.).—*R. E. Thompson.*

Storage on Distribution System Raises Pressures and Reduces Pumping. J. P. Schwada. Eng. News-Rec., **114**: 625–6, May 2, 1935. High sprinkling demand in Milwaukee reduced pressure in some districts to such extent that no water could be obtained. Comprehensive investigation revealed among other things that in some residential areas sprinkling demand was 8 times the yearly average. Volume of water required was relatively small, demand being at very high rate for short periods. Two 1.5-million gallon tanks were erected and favorable results obtained led to consideration of storage on large scale to take care of future pumping requirements beyond that due to sprinkling. In absence of natural site in high-service area, it was decided to erect tanks at ground level and instal booster station. Plan contemplates two 6-million gallon steel tanks, 165 feet in diameter and 37 feet high. One tank was erected and used in 1934, together with booster station housing 20-m.g.d. pump. Other tank will be erected later and station capacity increased according to

requirements. Tanks are used only in summer. They are filled at night and shut off automatically when full. One 1.5-million gallon elevated tank floats on line, the other elevated tank and booster station being operated only when demand is excessive. In one area where pressure was zero for periods as long as 2 hours, minimum pressure last year was 16 pounds, notwithstanding increased peak demand. Tanks have also reduced variation in pumping rates at major stations and postponed construction of another major station, tunnel, and feeder mains.—*R. E. Thompson.*

Indianapolis Pressures Improved and Pumping Costs Reduced. W. C. MABEE. Eng. News-Rec., **114**: 626–8, May 2, 1935. Charts are given showing pressures before and after erection of 1.5-million gallon elevated tank at extreme eastern edge of Irvington high-pressure district by Indianapolis Water Company. Tank is of radial-cone-bottom type, 97.5 feet to top and 25 feet deep (water depth), and floats on system at all times. Before installation of tank, heavy draft in district had established heavy pumpage record of 19 million gallons per day at Michigan booster station, located at western side of district, while after tank was placed in service, maximum pumpage rate was 9 million, leaving reserve capacity of 10 million, tank discharging at rate in excess of 10 m.g.d.—*R. E. Thompson.*

Kansas City, Kansas, Installs Five Tanks and Booster Districts. JAMES D. DONOVAN. Eng. News-Rec., **114**: 628–9, May 2, 1935. Since 1929, 5 booster districts have been created in Kansas City, each served by booster station and elevated tank, total elevated storage being 850,000 gallons, in addition to which, 13-million-gallon reservoir floats on system. It is estimated that cost of operation is $10,000 less per year than direct and continuous pumping, and resulting increase of from 5 to 10 pounds in pressure in several districts has permitted 10-pound decrease in pumping pressure at main station. Each station is equipped with 2 pumps, second unit operating only in event of excessive usage such as might be occasioned by fire.—*R. E. Thompson.*

Pre-stressed Concrete Standpipe Built in Vertical Panels. A. P. KURANZ. Eng. News-Record, **114**: 488–9, April 4, 1935. One of first pre-stressed concrete water tanks to be built with vertical instead of horizontal construction joints has just been completed at Waukesha, Wisconsin. Tank, of 675,750 gallons capacity, increases storage to about 1 million gallons, sufficient for 24 hours. Contract was let for $17,264.49 to lowest bidder. Stressing is effected according to Hewett system by tightening circular steel bands external to tank wall proper sufficiently to keep concrete in compression under all conditions, thus eliminating cracks. Inside diameter is 50 feet and depth 46 feet 1 inch to overflow. Roof is reinforced concrete dome, also of special Hewett design using ring of pre-stressed rods. Wall consists of shell uniformly 10 inches thick from top to bottom, reinforced vertically in both faces with round rods, and surrounded by horizontal rods tightened with turnbuckles. Outside there is 4-inch protective shell of concrete, reinforced vertically with round rods. Inside was waterproofed with asphalt emulsion. Not even a damp spot has appeared since tank was placed in operation. Outside wall was given archi-

tectural treatment by means of 12 pilasters. Tank, owing to monumental design, is considered asset to neighborhood; although, when first proposed, property owners were violently opposed to project. Construction was paid for out of accrued earnings. Extra water supply afforded improved city fire rating, reducing fire insurance rates 5 percent in business district, saving which will equal entire cost of project in 4 years.—*R. E. Thompson.*

A Year's Progress at Fort Peck. Constructing the Servicing Adjuncts. Eng. News-Rec., **114**: 659–64, May 9, 1935. Fort Peck Dam and collateral works are estimated to cost $86,000,000; $50,000,000 has already been allotted by PWA. Three main structures are dam, diversion tunnels, and spillways. Dam will contain 100,000,000 cubic yards of earthfill (mostly hydraulic fill), 4,000,000 cubic yards gravel in upstream and downstream toe fills, and 1,600,000 cubic yards rock riprap facing. Four diversion tunnels, of 6,317-foot average length and 32-foot unlined diameter, will be driven through faulted shale which disintegrates rapidly on exposure to air. Lining of tunnels will require 500,000 cubic yards of concrete. Spillway will involve 13,000,000 cubic yards of excavation and 540,000 cubic yards of concrete. Year's work, consisting of accessory works, is reviewed.—*R. E. Thompson.*

Diversion Tunnel Driving at Fort Peck Dam. Eng. News-Rec., **114**: 735–8, May 23, 1935. Methods being employed in construction of 4 parallel diversion tunnels are described and illustrated. Finished diameter will be 26 feet. Controlling construction condition is difficult material, dense marine shale that disintegrates rapidly on exposure to air. Outstanding construction features are: (1) asphalt coating of tunnel rock to delay disintegration; (2) rock saws operating on principle of coal cutter, capable of making circular cut 32 feet in diameter; (3) muck handling and spoil disposal by belt conveyors. Contract was let for $7,300,000.—*R. E. Thompson.*

Fort Peck Dam Diversion Tunnels. Eng. News-Rec., **114**: 898, June 20, 1935. Unit prices given from bids on contract awarded for $7,311,940, including inlet and outlet structures.—*R. E. Thompson.*

Sewer Tunnels Reduce Pollution in Chicago Drainage Canal. Eng. News-Rec., **114**: 83105, June 13, 881–6, June 20, 911–4, June 27, 1935. By driving 27 miles of intercepting sewer tunnels through sand, rock, and characteristic Chicago blue clay, and by building 2 new disposal plants and extending third, Sanitary District of Chicago is completing plan for treating practically all of city's sewage. Project will supplement dilution system involving reversal of flow of Chicago River, diversion from Lake Michigan for which must be reduced to 1500 second-feet by end of 1938 according to order of United States Supreme Court. Entire program, including 4 treatment plants, interceptors, and appurtenant works, will cost over $212,000,000. Driving and lining (concrete) procedures are described and illustrated.—*R. E. Thompson.*

Soft Ground and Lining Work on the Owyhee Project Tunnels. Eng. News-Rec., **114**: 804–7, June 6, 1935. Heavy ground, including serious flows of water

and sand at face, was outstanding feature of construction of 2 major tunnels of Owyhee Dam project of Bureau of Reclamation. Driving and lining (concrete) methods described and discussed.—*R. E. Thompson.*

Extensive Rock Grouting at Boulder Dam. Eng. News-Record **114:** 795–7, June 6, 1935. Details given of grouting operations at Boulder Dam. Grout holes were drilled in rock under dam and also through concrete lining of penstock and outlet tunnels. Particular attention was given to rock in vicinity of abutments; in these areas holes up to 150 feet deep were drilled from tunnels to provide continuous curtain of grout extending from dam into canyon walls. Pressures up to 1000 pounds per square inch were used.—*R. E. Thompson.*

Jacking 5-Foot Concrete Pipe Under Railway Fills. Edward L. Tracy. Eng. News-Record, **114:** 346–8, March 7, 1935. Details given of pipe jacking operations during reconstruction of sewer in Rutland, Vermont, including careful analysis of costs. Concrete pipe 60 inches in diameter was jacked total of 212 feet under 2 railroad embankments.—*R. E. Thompson.*

Comparison of Steel and Concrete Pipe Lines. Eng. News-Rec., **114:** 692, May 9, 1935. Tacoma, Washington, let contract in January for 44,846-foot Green River gravity pipe line based on lowest annual cost of various combinations of steel (with different types of protection) and concrete pipe as revealed by bids on 7 alternative propositions. Details of bids given.—*R. E. Thompson.*

Large Steel Main Cleaned Under Water. Arthur T. Clark. Eng. News-Rec., **114:** 356–7, March 7, 1935. Technique employed in cleaning 48-inch riveted steel intake pipe of Hammermill Paper Company, Erie, Pennsylvania, is described. Lake end of intake, which is 2000 feet long, terminates in 48-inch vertical tee with plain bell mouth in 30 feet of water, opening being protected by 25-foot square timber crib. Shore end discharges into pump well through enlarged 90° elbow, with drop pipe extending to within few feet of well bottom. Section cut from pipe indicated that tuberculation was uniform throughout entire inner surface, being about ⅝-inch thick, with prominences up to 2 inches in height and 3 inches in diameter. Tuberculation in general was comparatively soft. It was estimated from observations on test section that tubercules in entire line would occupy volume of about 200 cubic feet and weigh about 8 tons. There was no indication of corrosion. Pipe was fabricated of open-hearth steel and was coated with asphaltum when laid in 1911. Details are given of machine used, which was inserted and removed through vertical tee at lake end of intake. Before cleaning, observations indicated value of C (Williams and Hazen formula) to be 57, and maximum rate of flow under permissible loss of head to pumps was 25 million gallons per day. After cleaning, value of C was 87, and indicated maximum flow was 35 million gallons and higher under permissible operating conditions.—*R. E. Thompson.*

Slide Rule for Routing Floods Through Storage Reservoirs or Lakes. Chesley J. Posey. Eng. News-Rec., **114:** 580–1, April 25, 1935. Construction and use of slide rule for determining effect of reservoir, pond, or lake storage on flood wave described and illustrated.—*R. E. Thompson.*

Reactions at Pipe Bends in Water Distribution Systems. IRVING GOLDFIEN. Eng. News-Rec., **114**: 566–7, April 18, 1935. High pressure fire protection system under construction in Milwaukee will be operated under pressure of 300 pounds per square inch. Test pressure for acceptance has been set at 450 pounds. Pipe sizes to date range from 12 to 20 inches in diameter and large number of bends occur throughout system. As substitute for combined formulas for static and dynamic forces: $E = 2A\left(P + \frac{WV^2}{g}\right) \sin \frac{\theta}{2}$, which requires separate calculation for each condition, author devised diagram (shown in figure) which permits direct determination of reaction for any given conditions under assumed velocity of 10 feet per second. Deviation from this velocity would not appreciably affect final result. Chart gives reactions for all ordinary conditions with pipe diameters of 12 to 72 inches.—*R. E. Thompson.*

Protection Against Scour Below Overflow Dams. E. W. LANE and W. F. BINGHAM. Eng. News-Rec., **114**: 373–8, March 14, 1935. From study of literature and results of hydraulic laboratory studies on dam spillways carried out by United States Bureau of Reclamation, analysis has been developed by authors which classifies the various conditions and points out general types of protection applicable to each. Present tendency is to dissipate energy in some form of stilling pool, or to divert high velocity stream so that it does not come in contact with bottom where damage will result. Most important factor in determining form of protection is depth of water on downstream side of dam and its relation to depth required to form hydraulic jump. In case of dam with well-formed jump at toe, velocity is so quickly and uniformly reduced that little scour results. It is therefore desirable, whenever possible, to design dam so that jump will occur, protection required being thus reduced to minimum. By means of relation between stage-discharge, or tailwater rating, curve and jump-height curve, conditions are divided into 4 classes, protection required in each being discussed and examples given and illustrated.—*R. E. Thompson.*

Flow Over Rounded Crests. A New Formula Offered. J. J. DOLAND. Eng. News-Rec., **114**: 551, April 18, 1935. Conventional formula for flow over rounded crest weirs, $Q = CLH^{\frac{3}{2}}$, is not entirely satisfactory for measuring or designing purposes on account of variations of C for different values of H. Coefficient C for sharp crested weirs remains same throughout range of heads and, as is well known, curvature of lower nappe is more or less fixed within given range of head by crest shape. It is also known that curvature of streamlines affects pressure distribution throughout jet. Therefore, it seems reasonable to suppose that there might be relation between curvature of crest and head which would have something to do with coefficient of discharge. Experimental data were collected and analysed on this basis and there appears to be evidence that formula might be modified to following form. $Q = \frac{K}{(R/H)^n} \cdot LH^{\frac{3}{2}}$ or $Q = \frac{KLH^{\frac{3}{2}+n}}{R^n}$ in which Q, H, and L have their usual significations, K is a

constant, R is radius of curvature of weir crest, and n is exponent which remains constant when water remains in contact with rounded crest. In other words, C of conventional formulas becomes $\frac{K}{(R/H)^n}$. Graph is given showing results of plotting expression for C from experimental data derived from several sources. Principle, if correct, would provide direct method of determining coefficient of discharge over dam from study of crest shape.—*R. E. Thompson.*

Utah Supreme Court Decision Confuses Underground Water Law. C. J. ULRICH. Eng. News-Rec., **114**: 487–8, April 4, 1935. Utah water-rights law, enacted in 1903, accepted doctrine of prior appropriation and provided for acquisition of rights to public water by application to state engineer. As result of prominent court decision there has grown up an accepted, although unwritten, water code which has excepted artesian and percolating water from classification of public water and considered such water as property of soil. Recent decisions, however, have confused the situation. Salt Lake City is vitally interested, having acquired by purchase a number of artesian wells in 1931 and since that time developed additional ones to supplement supply from canyon streams. Strenuous objections have been raised by other artesian well owners and legal action is imminent. Legislation has been submitted to state legislature providing for all underground water to be considered public water, subject to appropriation and under control of state engineer, all existing rights to be recognised. (Footnote by editor states that bill was signed by Governor BLOOD on March 22.)—*R. E. Thompson.*

Emergency Measures Defer Approaching Water Shortage. MELOY SMITH. Eng. News-Rec., **114**: 618–20, May 2, 1935. Principal supply of Rochester, New York, is derived from Hemlock-Canadice watershed. Central business portion of city is served by high-pressure fire system which in recent years has also been supplied with Hemlock water. Portions of 5 wards and most of towns contiguous to city are served by Rochester and Lake Ontario Water Service Corporation, subsidiary of Federal Water Service Corporation, which derives supply from Lake Ontario. Hemlock Lake, a glacial lake 30 miles south of city and 400 feet above it, has been used as source of supply since 1876. Canadice Lake, which parallels Hemlock Lake, 2 miles to east and 200 feet higher, was added to system in 1919. Stream into which this lake empties is led into Hemlock Lake, from which 3 gravity conduits lead to city. In May, 1934, it became apparent that lakes were not going to fill and that estimated safe yield of 30 million gallons per day from Hemlock-Canadice watershed was too high, necessitating several modifications in operating procedure. Changes included reintroduction of Genessee River water into high pressure system, requests to citizens to dispense with sprinkling, inauguration of intensive leakage survey, modification of conduit system to enable drawing of water from lower level in lake, and purchase of water from Eastman Kodak Company and from Rochester and Lake Ontario Water Corporation. The Kodak Company water, which is derived from Lake Ontario and filtered through slow sand filters, is sterilized with ammonia-chlorine before intro-

duction into mains. Supply from Lake Ontario has been recommended as permanent solution of difficulties and petition has been made to State Water Power and Control Commission to construct 10-m.g.d. plant 8.5 miles west of mouth of Genessee River.—*R. E. Thompson.*

Present Status of Water Softening. E. W. Johnston and A. T. Byram. Eng. Contract Record, 49: 267–8, 1935. There are 149 public water supplies in Ontario with total hardness in excess of 100 p.p.m. Tabulated operating data for year 1934 are given for Etobicoke Township zeolite plant, the only softening installation in the province. Cost of operation and maintenance was 8.11 cents, and fixed charges, 4.62 cents per 1000 gallons. Salt used per 1000 grains of hardness removed averaged 0.392 pound. Hardness was reduced from 323 to 86 p.p.m. and iron from 1.4 to 0.4 p.p.m. Waste and backwash water averaged 11.92 percent.—*R. E. Thompson (Courtesy Chem. Abst.).*

Ohio Valley Well Supplies Subject to Slow Reduction of Capacity. O. E. Meinzer. Eng. News-Rec., 114: 621–2, May 2, 1935. Discussion of geology and ground water supply of Ohio Valley. There are probably 700 to 800 public supplies in drainage basin which derive water from wells which vary widely in depth, rock penetrated, and quantity and quality of water produced. Salt water underlies practically whole basin but comparatively little salt water contamination has thus far been reported. Many cities both in Ohio River Valley and throughout United States have adequate ground water resources, but lack basic information needed for systematic development, which could be obtained by hydrologic investigation and continuous records of levels in properly located observation wells and pumpage from producing wells. It is time to apply commonsense procedure to this major national problem, in order that reliable periodic inventories can be made of water resources.—*R. E. Thompson.*

Deer Creek Water Project, Shawnee, Oklahoma. Eng. News-Rec., 114: 470–1, March 28, 1935. Contracts were awarded December 10, 1934, for project which includes earth dam, 5.5 miles of 27-inch concrete pipe, 3 miles of 20-inch steel pipe, filter plant, pumping station, and mains. Unit prices given.—*R. E. Thompson.*

Determination of Residual Chlorine. R. D. Scott. Water Works and Sewerage, 83: 2, 58, February, 1935. A historical résumé, coupled with author's experience and experiments. Scott concludes that: (*a*) sunlight causes fading of samples to which *ortho*-tolidine has been added, after 5 minutes; (*b*) residuals should be read at 20°C., otherwise readings are too low; and (*c*) too long standing allows false color development. Iron and manganese interference is eliminated, and that from nitrites reduced, by precipitation of the Fe and Mn with sodium hydroxide in presence of magnesium sulfate. Sodium hydroxide must be free of chlorine demand. Use of more acid *o*-tolidine reagent minimizes nitrite and ferric iron errors and speeds color development. Testing samples at low temperature reduces iron and nitrite errors though giving a low chlorine reading. Starch iodide test is described

as a method of preventing errors if acid is not used in indicator. This test is most sensitive at low temperatures. Weaknesses in earlier methods of eliminating false tests are pointed out. Methyl orange differentiation between chlorine and chloramines is described. Twenty-five references.—*H. E. Hudson, Jr.*

Commission Form of Water Department Control. How it Works at Waco, Tex. Dr. S. R. SPENCER. Water Works and Sewerage, 82: 3, 77, March, 1935. Five elected commissioners serve staggered 2-year terms, without compensation. Department is separate entity in every way. Complete freedom from political interference has resulted in high type of personnel, economical operation, and adequate supply.—*H. E. Hudson, Jr.*

Leakage Survey Profitable Work Relief Project. Anon. Water Works and Sewerage, 82: 3, 82, March, 1935. At Lancaster, N. Y., unaccounted for water was reduced from 42 to 19 per cent by survey.—*H. E. Hudson, Jr.*

The New Water Supply System of Holland, N. Y., a PWA Project. NEWELL L. NUSSBAUMER. Water Works and Sewerage, 82: 3, 83, March, 1935. Obsolete system was replaced with new one which comprises: adequate distribution system, 180-foot rock well, well pump, Aeromix, chlorination, service pumps, and steel elevated storage tank. Equipment operates automatically: total cost was $105 per capita.—*H. E. Hudson, Jr.*

A Study of Filtering Materials for Rapid Sand Filters. Part 5. The Sand-Gravel Interface. J. R. BAYLIS. Water Works and Sewerage, 82: 3, 89–93, March, 1935. Article describes in detail painstaking observations on what happens at sand-gravel interface. Many observations on glass walled filters proved that wash water passes unevenly through the gravel, shooting into the sand at certain points with velocities as high as 10 times the average. This jet action is illustrated by 11 well chosen drawings. Study of these observations led to following conclusions: (*a*) most troubles occurring in filter beds originate at sand-gravel interface; (*b*) improper size grading accentuates troubles: customary grading is unsatisfactory; (*c*) jet action at sand-gravel interface causes shifting of the gravel, which sometimes allows sand to pass down through the gravel; (*d*) jet action is unavoidable; and (*e*) sand in filter causes gravel movement to occur at one-third the wash rate which would move the gravel in absence of sand.—*H. E. Hudson, Jr.*

Practice in Replacement of Water Meters. CHARLES L. RUCKMAN. Water Works and Sewerage, 82: 3, 98, March, 1935. Meter and Service division of Los Angeles has 257,000 meters. When meters become inoperative, or over- or under-register, they are tested and, if necessary, repaired. In year 1933–34, 5.8 percent of meters were removed, repaired, or tested. Meters are read monthly. For irrigation water, each service has a meter from which "works" are removed when not in use. This results in considerable saving. All meters are set in concrete boxes inside street line. Durability tests, carried on for many years, have led to specifications to which all meters are built. Graphs show how this has improved meter life.—*H. E. Hudson, Jr.*

The Hydraulics of Rapid Sand Filters. G. Gale Dixon. Water Works and Sewerage, **82**: 4, 103–107, April, 1935. Discussion of some leading studies in sand hydraulics and filter washing. Calculation of loss of head through the filter is explained. Two designs of filter underdrains are compared; the perforated pipe system and the Wheeler bottom. Detailed analysis shows total loss of head in back-washing to be considerably less for the Wheeler bottom; while cost of Wheeler bottom was $1,125 per m.g.d. capacity, as against $1,216 for perforated pipe.—*H. E. Hudson, Jr.*

Let's Have a New Deal for Government Personnel! Harry E. Jordan. Water Works and Sewerage, **82**: 4, 108, April, 1935. Advocates "career service" for water works employees, wherein employees would hold their positions securely on merit alone.—*H. E. Hudson, Jr.*

Reminiscing on the Installation of Mechanical Filtration. Three Decades Ago at Cincinnati. Ira H. Jewell. Water Works and Sewerage, **82**: 4, 112, April, 1935. Of historical interest, this paper describes the pioneer work at Cincinnati.—*H. E. Hudson, Jr.*

Hydrant Discharge Measurements and Application to Problems of Water Works Operators. P. S. Wilson. Water Works and Sewerage, **82**: 4, 115–119, April, 1935. Extensive discussion of measurement of velocity head of hydrant discharge. Two methods are given: use of Pitot tube in discharge stream, and measurement of pressure in hydrant barrel. Technique is described. Both methods give similar results. Pressure reading, with nozzle size known, can be converted to rate of flow. Useful table and graph are given. Methods described can be used for fire flow tests, main size determination, friction studies, etc.—*H. E. Hudson, Jr.*

A Presentation of Representative American Waterworks Plants. Anon. Water Works and Sewerage, **82**: 4, 143–166, April, 1935. Excellent collection of photographs of water works plants.—*H. E. Hudson, Jr.*

Money Saving Methods in Purification Plant Operation. W. H. Lovejoy. Water Works and Sewerage, **82**: 5, 169, May, 1935. At Louisville, Ky., plant forces were utilized to revamp filters and dismantle battery of old filters. Filter sand obtained locally, after backwashing and scraping, was found satisfactory. Mule-drawn scrapers, aided by high-pressure hose streams, gave improved settling basin cleaning. One-ton chlorine containers were substituted for small cylinders, and quicklime, for hydrated lime. Flocculators were installed. Savings resulting from these innovations have totalled $97,515 since 1921. Detailed figures are given.—*H. E. Hudson, Jr.*

Reviewing Boiler Water Conditions. O. L. Anderson. Water Works and Sewerage, **82**: 5, 178, May, 1935. Discussion of problems of railroad water supply and their solution. Proper treatment of water has greatly increased life of flues. Treatments used by Atlantic Coast Line R.R. are described. It was sometimes found more economical to change to new supply rather than treat existing one.—*H. E. Hudson, Jr.*

Electron-Shells, Electron-Atmospheres, and Weather. HALBERT P. GILLETTE. Water Works and Sewerage, 82: 5, 186, May, 1935. FARADAY'S magnetic theory of weather changes is discussed, in light of present knowledge of "KENNELLY-HEAVISIDE" layer.—*H. E. Hudson, Jr.*

Filtered Water Served at Well Water Temperature. WM. M. RAPP. Water Works and Sewerage, 82: 5, 188, May, 1935. Copper coil, surrounded with gravel, buried in well dug with post hole auger, cooled water to 66°F., at Atlanta, Ga.—*H. E. Hudson, Jr.*

Use of Inhibitors in Cleaning Metallic Pipe. ALLEN ABRAMS and C. L. WAGNER. Water Works and Sewerage, 82: 5, 192, May, 1935. Small quantities of certain organic inhibitors, added to acid solution, allow dissolving of rust, or scale, but prevent solution of metal. After successful experiments, pipes in one building were cleaned at 10 per cent of replacement cost.—*H. E. Hudson, Jr.*

Results from Activated Carbon Applied to a Reservoir. MARSHALL S. WELLINGTON. Water Works and Sewerage, 82: 5, 193, May, 1935. At New Haven, Conn., copper sulfate, followed by powdered activated carbon, treatment of reservoir reduced green color from 40 to 10. Carbon settled out satisfactorily and decomposition tastes consequential upon copper sulfate treatment were prevented. *H. E. Hudson, Jr.*

Anthracite and Sand as a Filter Medium. O. J. RIPPLE. Water Works Eng., 88: 6–277, March 20, 1935. Filters with 14 inches of sand, of effective size 0.52 mm. and uniformity coefficient 1.72, and 6 inches of anthracite, as near as possible to 0.80 mm. size throughout, were used as experimental units. The combination of anthracite and sand has given much better performance than sand alone, as to length of run, as to rate of filtration, and as to percentage of wash water. Results on filter containing 48 inches of 0.60 mm. anthracite are tabulated and show that it produced 28 percent more water than a similar sand filter. Results at Denver have demonstrated the value of anthracite as filtering medium, either alone, or on top of sand. Author belives that depth of anthracite could be reduced to that of sand beds and still give a good effluent.—*Lewis V. Carpenter.*

The Law as to Diversion of Water. LEO T. PARKER. Water Works Eng., 88: 6–283, March, 1935. The courts have held that in order to secure valid appropriation of water three elements must exist: (1) appropriation for some beneficial use, existing at the time, or contemplated in the future; (2) a diversion from the natural channel by means of a ditch, canal, or other structure; and (3) application within a reasonable time to some useful industry. Water user's rights to water cease after it has escaped from his possession. Courts have held that water usage must be beneficial. Municipality may, if need be proven, impound flood waters, regardless of rights of riparian owners. When user interferes with course of stream, or brings water on to his property which would not naturally have come upon it, he is responsible for damages caused by escape of the water, unless escape was caused by an agent beyond his

control. The general rule is that an officer of a corporation, who takes part in the commission of an injurious act by the corporation, is personally liable therefor.—*Lewis V. Carpenter.*

Million-Gallon Supply for $70,000. James P. Wells. Water Works Eng., 88: 329, April 3, 1935. Water supply for Pulaski, N. Y., comes from springs situated about three and one-half miles east of town which flow about three million gallons per day. Two circular concrete basins collect of this water 1,300,000 gallons per day, which is piped by gravity to the town.—*Lewis V. Carpenter.*

Regulations for Meter Accuracy. N. N. Wolpert. Water Works Eng., 88: 7, 325 and 88: 8, 379, April 17, 1935. Results of comparative survey of rules and regulations enforced by various State Public Service Commissions as to frequency of meter tests and as to manner in which meters should be tested. Excerpts from the various regulations are included.—*Lewis V. Carpenter.*

Laws on Acts of Water Officials. Leo T. Parker. Water Works Eng., 88: 7, 331, April, 1935. In cases involving injuries to citizens caused by defective sidewalks etc., courts will invariably hold city liable for damages if defect had been in existence for at least three weeks. Contributory negligence, on part either of employee or of pedestrian, is any act which results in an injury, which could have been prevented by using an ordinary degree of care to observe any and all dangerous conditions existence of which he should have anticipated. Municipality may be liable in damages for injury to real property resulting from construction of water pipes beneath public streets. One case is cited where franchise had been given to private company to construct a main, which subsequently reverted to city, and courts held city liable for property damage after main had been taken over. City officials may be personally liable on *ultra vires* contracts, which are contracts intending to bind or obligate the city, made by officials having no direct authority so to bind the city.—*Lewis V. Carpenter.*

Reducing Fluorine Content of Water. Anon. Water Works Eng., 88: 8, 385, April 17, 1935. Severe mottled enamel of deeply stained and pitted type appears to be associated with waters containing well over 2.0 p.p.m. of fluorine; but no Arizona water known to contain more than 1 p.p.m. fluorine has failed to cause mottled enamel. Widely varying values of 12.0, 8.0, 7.2, and 6.8 p.p.m. were found for fluorine content of same water sample when tested by four different methods. Bone, added at rate of 67.6 p.p.m., reduced fluorine content from 2.5 to 1.7 p.p.m. Aluminum sulfate and activated carbon have both been tried with some success, but are too costly to be practical.—*Lewis V. Carpenter.*

Modern Filter Plant Control. Harry E. Jordan. Water Works Eng., 88: 9–452, May 1, 1935. Three major trends in design and operation of treatment plants are evident: (1) application of contact principle to accelerate

sedimentation; (2) focussing of attention upon upper layers of sand; and (3) recognition of need for continuous study of dosages and points of application of treatment chemicals for taste and odor control. Phenomenal success of SMITH's flocculator at Richmond is valuable illustration of first trend: author feels that continuous removal of sludge is here desirable. Preferability of jetting, or surface washing, to high velocity wash illustrates the second. As to the third, each filter plant operator must study his own problems on taste and odor control and should make it his aim that application of corrective measures should at no time exceed necessary minimum. Two other features go a long way in securing satisfactory operation, namely, a clean plant and a self-respecting personnel.—*Lewis V. Carpenter.*

Plan to Remodel Cincinnati Purification Plant. C. S. TIMANUS. Water Works Eng., 88: 9–454, May 1, 1935. Original plant, built in 1907, has undergone no major changes. Sloping sides of existing basins are to be made vertical, thereby increasing their capacity from 22 to 30 m.g., without increasing their area. Filters are to be completely modernized by additional wash water troughs, new sand and gravel, and reconstruction of underdrain system. It is proposed to construct new pipe galleries and influent flumes along the backs of existing filters. Number of filters will be increased from 28 to 50 without its being necessary to throw more than one filter out of operation at any one time. New chemical house will be equipped for applying lime and iron, alum, soda ash, and carbon. Cost of improvements will be $3,000,000.—*Lewis V. Carpenter.*

Experiments with Slow Sand Filtration. CALEB MILLS SAVILLE. Water Works Eng., 88: 9, 457, May 1, 1935. Slow sand filtration effluent can be safe without use of germicides. Essential conditions justifying its adoption are that waters should be of low turbidity and color and free from acid constituents. First cost of construction is undoubtedly about 50 percent more than that of rapid sand plant of similar capacity. Sand at Hartford is cleaned by using gasoline-driven tractor machine of Bayard pattern which washes the sand in place and ejects refuse to waste channel. Cost of operation for 1934 reached the low figure of $2.53 per m.g. Operating data from Providence, R. I., Cambridge, and Springfield are given. At Springfield, coagulant is needed at times on account of high color, average for 1933 being 32, with high of 48.—*Lewis V. Carpenter.*

Service Pipe Friction Losses. JAMES E. GIBSON. Water Works Eng., 88: 9, 467, May 1, 1935. Friction losses in feet of head per 100 feet length are given for various types of house service connections. Diagrams are shown for lead, copper, and galvanized pipe, at flow rates ranging from 5 to 50 gallons per minute and for loss of head up to 180 feet per 100 feet of pipe; meter in each case being set at sidewalk curb. Service line and meter account for majority of head loss. Superiority in this respect of lead both to copper and to galvanized iron is manifest. The standard "K" copper service tubing is, however, an ideal material for the purpose, because of its sustained delivery, non-corrodibility, low cost, durability, ease of installation, and salvage value.—*Lewis V. Carpenter.*

Why Pipe Thawing Starts Fires. Fred Shepperd. Water Works Eng., **88**: 9, 472, May 1, 1935. In completing an electric circuit, electricity in the larger quantity will flow along the path of least resistance. Hence in thawing jobs, current may find for itself an adventitious path back to the transformer and cause a fire. It frequently enters the house wiring with disastrous effects. Author illustrates by diagram fire hazard during thawing operations. Surest method for preventing trouble is to disconnect the plumbing inside the building before starting electric thawing operations of any kind.—*Lewis V. Carpenter.*

Detection of Flaws in Protective Coatings. G. W. Clarvoe. Water Works Eng., **88**: 9, 483, May 1, 1935. Bituminous coating material for metallic pipes is usually of good quality and for most of defects found, method of application is to blame. Until recently, the only criterion of a coating job was its appearance; and as the naked eye is unable to detect small craters, pin holes, etc., many a poor coating job was approved and buried. An electrical flaw detector has been developed for testing coatings, based on principle that the instantaneous dielectric strength of asphalt, or coal tar, pipe line enamel is greater than that of air. Enamel is subjected, for a brief interval, to an electrical voltage sufficiently high to break down any very thin pockets of the coating which are not considered sufficient for underground protection of the pipe. Source of high voltage stress is a spark coil, or transformer, delivering a secondary voltage of from 10,000 to 75,000. Instrument is usually adjusted to give breakdowns on coating spots thinner than $\frac{1}{32}$ inch.—*Lewis V. Carpenter.*

Construction Costs of Small Water Supplies. James P. Wells. Water Works Eng., **88**: 10, 566, May 15, 1935. Detailed construction costs on unit prices of dams and pipe lines during period from 1915 to 1934. Pipe diameters ranged from 6 to 14 inches.—*Lewis V. Carpenter.*

Odor-Control Methods Aided by New Test Equipment. M. W. Cowles. Eng. News-Rec., **114**: 636–7, 1935. Brief discussion of measurement of odor of water by progressive dilution with either air or water, using a constant dilution ratio of 1:2, until the limiting or "threshold" concentration is reached. This method, proposed by Fair, is based on the psycho-physical law of Weber and Fechner that an arithmetic increase in sensory-odor intensity corresponds to a geometric increase in the amt. of odor-producing substance. The dilution at which the odor just ceases to be detectable is called the pO value and results of determinations can thus be subjected to statistical analysis. Use of an osmoscope facilitates detection of odors. Apparatus for odor determinations must be kept clean and free of odors. Immersion in tap water containing activated carbon when not in use is advisable.—*R. E. Thompson (Courtesy Chem. Abst.).*

Water Purity Endangered by Diversion of Water Funds. George N. Schoonmaker. Eng. News-Record, **114**: 643–4, May 2, 1935. In January, 1934, owing to use of water works funds for other municipal purposes, there was less than $25,000 in cash for water works purposes in Toledo, Ohio, al-

though book balances showed cash surplus of more than $1,000,000. Fortified by court decision in January, 1934, ordering water works funds to be held on deposit entirely separate and distinct from other city funds, cash surplus has grown to about $250,000 and by end of 1935 reserve is expected to be approximately $400,000. Water works funds cannot be diverted legally to general fund in Ohio except as charge for services rendered by other city departments. —*R. E. Thompson.*

Water Funds Widely Used to Supplement Tax Revenues. N. T. VEATCH, JR. Eng. News-Rec., **114:** 644, May 2, 1935. Prior to depression period, state statutes generally forbade transfer of funds from one department to another; but with decreasing revenues from taxes and increasing demands for funds for relief purposes, tendency has been to change statutes to permit diversion. Diversion of funds from municipal income-producing utilities to maintain governmental activities is unfair and unjust. Financial program should be carefully planned covering 5-year or longer period, budgeting expected income and expenses, including depreciation and sinking fund charges, for each year. This practice would discourage diversion of funds to other departments.—*R. E. Thompson.*

Meters and Meter Records Present Economy Opportunities. A. S. HIBBS. Eng. News-Record, **114:** 641–2, May 2, 1935. Immense economies may be effected by simplification and coordination of forms and records.—*R. E. Thompson.*

Water Consumption Rises: Many Supplies Require Expansion. NICHOLAS S. HILL, JR. Eng. News-Rec., **114:** 616–8, May 2, 1935. Data assembled for more than 100 of larger cities of country for period 1925–34 are summarised and discussed. Consumption data are shown graphically in form of yearly indices based on year 1926 as 100. For country as whole, consumption remained stable in 1930 but fell sharply thereafter and reached lowest point in 1933. Increased business activity in 1934 caused sharp rebound to point above that of 1926, equal to about that of 1927. From curve of general business shown in same figure, it is evident that water consumption index lags about 1 year behind more sensitive barometers such as Federal Reserve Board index of industrial production and is not subject to such violent fluctuations. In 1933, when industrial consumption was only 77.5 per cent of 1926, domestic consumption and unaccounted for water were about same as in 1926. Developed yields of supply sources of communities studied were also assembled and attempt made to determine limit of capacity of each supply. From these data it appears that about 25 per cent of systems require additions to sources of supply to meet probable demands if present gains in consumption hold and continue to advance even moderately.—*R. E. Thompson.*

Hetch Hetchy Reservoir Extension. Eng. News-Record, **114:** 540, April 11, 1935. Unit prices given from 3 low bids on contract let in January for $3,219,965 by San Francisco Public Utilities Commission for raising of O'Saughnessy Dam 85.5 feet.—*R. E. Thompson.*

The Scale-Buoy System of Processing Water. Norman J. Howard. Eng. Contract Record, **49**: 372–4, 1935. Illustrated description of the scale-buoy method of water treatment devised by H. R. S. Abbott. The treatment consists simply of immersing scale-buoys, which are glass vessels containing 3 inert gases and a small amount of treated mercury in the water and agitating. Most common application of process is in prevention of scale in boilers; but treatment is also employed for conditioning water for industrial processes and for laundry and domestic use. It is claimed that a considerable saving in soap can be exected.—*R. E. Thompson (Courtesy Chem. Abst.).*

Frequency, Extent, and Severity of Droughts Since 1881. Lloyd L. Harrold. Eng. News-Rec., **114**: 478–9, April 4, 1935. Distribution of precipitation throughout year, temperature, and wind are important factors in damage resulting from drought; but, in general, serious drought effects do not result unless annual precipitation is as low as 85 per cent of mean. Tabulation, based on records of United States Weather Bureau, is given, showing number of years in period 1881–1934 when deficiency was 15, 20, 25, or 30 per cent or more of 50-year mean and the 6 years of lowest precipitation for each state. Since 1880 there have been 38 drought years in the 31 humid states and 29 in the 5 semi-arid states. In former, interval between droughts has ranged from 3 to 7 years and in latter, from 2 to 8 years. Judged by area affected and deficiency of precipitation, 1930 was year of most severe drought record in humid states, next two being 1894 and 1901; while in semi-arid states, 1934 was most severe, next two being 1894 and 1910. In semi-arid states, drought years have been more or less bunched, with several successive normal years intervening.—*R. E. Thompson.*

Additional Data on Model Tests for Boulder Dam Spillways. D. C. McConaughy. Eng. News-Rec., **114**: 480–2, April 4, 1935. Discussion of model tests made by E. Meyer-Peter and Henry Favre (Eng. News-Rec., October 25, 1934, p. 520) pointing out short-comings in their design and remedies.—*R. E. Thompson.*

A Method of Calculating Efficiency of Filtration. Herbert E. Hudson, Jr. Eng. News-Rec., **114**; 528–30, 1935. Data obtained at the Chicago experimental filtration plant, which includes rectangular units of concrete and circular units of steel and of glass-tube, are used to illustrate method for computing the efficiency of filter plants. Efficiency, which is defined as the ratio of actual output of plant to its nominal capacity (filter area x filtration rate employed), depends upon length of runs, upon rate of filtration, upon amount of wash water used, and upon time during which filters are out of service for washing. Tabular and graphical data on filter runs and on clogging rates are given to show that relation between filtration rate and length of filter run can be expressed by the equation, $H = \frac{K}{V^n}$, where H = filter run, in hours, to 8-foot loss of head, K = a constant, dependent upon treatment of water prior to filtration, V = rate of filtration in gallons per square foot per minute, and n is an exponent, value of which for the Chicago data is 1.5.—*R. E. Thompson (Courtesy Chem. Abst.).*

Welded Steel Pipe Arched Across Unstable Ground. Eng. News-Rec., **114:** 342, March 7, 1935. Welded steel pipe in form of arch to cross stretch of unstable ground was employed in pipe line used to convey potable water to Lausanne, Switzerland. Ground at point in question consists of clayey calcareous marl and mud and constant movement occurs, depth to which these conditions exist precluding use of tunnel. Line is 50 centimeters in diameter, span of arch 42 meters, and rise 7 meters. It was designed as arch with fixed abutments and supported at each end, with ribs to add to rigidity. Plates are 12 and 15 millimeters thick and 1 meter long, thicker plates being used toward ends. Working pressure in line is 29.5 pounds per square inch. Air valve was placed in center of arch.—*R. E. Thompson.*

St. Thomas, Ontario, has Water Treatment Plant with Unusual Operating Features. Eng. Contract Record, **49:** 248–52, March 27, 1935. Illustrated description of water treatment plant at St. Thomas, which was placed in operation 3 years ago. Water supply is derived from catchment area of about 60 square miles, a 350-million gallon impounding reservoir being located about 0.5 mile upstream from plant. Rainfall averages about 37 inches per year and runoff about 15 inches. Watershed is almost entirely cultivated land and flood flow is induced by rainfall of 1 inch. After heavy rain, water may contain up to 3000 p.p.m. of very fine turbidity. In ordinary years there is for a long period in summer no outflow from reservoir except that drawn for water supply and as average depth of reservoir is only 7 feet (maximum 30 feet), water is very susceptible to changes in temperature and to occurrence of taste. After retention period of about 2 days in preliminary settling basin, water is treated with chlorine and alum, aërated, passed through spiral flow conditioning tanks, settled, filtered, and finally chlorinated. Raw water is moderately hard (180 p.p.m.) and has pH value ranging rom 8.4 in summer to 7.6 in spring. Retention period in conditioning tanks is 90 minutes and settling period is 3 hours. Filters, of which there are 4, have capacity of 1 m.g.d. each at rate of 110 m.g.a.d. Filter beds consist of 20 inches of graded gravel and 28 inches of 0.55 millimeter sand. Customary wash rate is 30 inches rise per minute and wash water used averages 2.5 percent. Filter runs are terminated at 48 hours throughout year. Effluent from each filter is made visible to operator by means of small white enamelled basins with plate glass mirrors in bottom through which filtered water flows continuously. Initial dose of chlorine varies from 0.5 to 1.0 p.p.m. and final dose from 0.3 to 0.4 p.p.m.—*R. E. Thompson.*

Pumping Station and Service Buildings for Toronto's Duplicate Water Supply. Eng. Contract Record, **49:** 529–32, June 26, 1935. Work is actively proceeding on last of major units of new Victoria Park plant, the pumping and chemical feed section, contract for which was awarded for $1,255,112. Pumping station will be all-electric driven, without auxiliary power other than relatively small supply from storage batteries, for operating switching equipment, emergency lights, etc. Whole electrical system will be in duplicate, power being furnished through 2 underground cables. Station will be 295 x 84 feet, divided into 4 parts, namely, intake and screen, low lift, high lift, and administrative and control sections. In addition, there will be several valve and

meter chambers with interconnecting galleries and a substantial group of service buildings. Screen section will contain 4, and ultimately 8, mechanically-operated traveling screens. The 4 low-lift and 4 high-lift pumps will be driven by synchronous motors. Provision has been made for increasing capacity when occasion demands. Alum will be delivered to plant by motor truck, conveyed to storage bins by pneumatic equipment, and applied to water through dry feed machines.—*R. E. Thompson.*

Springs and Wells Form Sources of London, Ont., Water Supply. E. V. Buchanan. Eng. Contract Record, **49**: 244–7, March 27, 1935. Illustrated description of London, Ontario, water works system, dating from 1878, when population was less than 20,000. Original source of supply, group of springs located some 4 miles west of city on banks of River Thames at Springbank, has continuously delivered approximately 3 m.g.d. since that time. Cost of original works was about $300,000 and $2,450,000 has since been added to investment. In 1909, Beck Wells plant was constructed, which consists of 4 wells, 10 and 12 inches in diameter, raw water basin, aërating tower, settling tank, 6 pressure filters, and million-gallon reservoir and has average output of 1 m.g.d. Later, 3 more wells, located 2 miles to south, producing 0.75 m.g.d. were added. Well water contains as high as 3 p.p.m. iron and traces of hydrogen sulfide. Aëration and filtration plant, which has capacity of 3 m.g.d., satisfactorily removes these objectionable constituents. To provide for future demands, 6 wells have since been developed in east end of city and 10 within mile of northern boundary. There are 23,303 services, 100 percent metered, and daily per capita consumption is 66.7 gallons. About 84 percent of pumpage is accounted for. Water is of excellent bacteriological quality, but chlorination is employed as precautionary measure. Hardness averages 18 to 20 grains per gallon. Water works has always been self-sustaining. Average domestic bill is $12.42 per year.—*R. E. Thompson.*

London, Ont. Experience with Water Meters. T. Hodkinson. Eng. Contract Record, **49**: 254–7, March 27, 1935. General policy of metering was adopted in 1922, program being practically completed at close of 1925. Cost averaged $14 per meter installed. Effect of metering on consumption is shown graphically. Per capita use reached 91 gallons per day in 1920 and dropped to 60 in 1926, since when there has been slight increase. Prior to 1925, minimum flat rate was applied unless consumption exceeded 800 cubic feet per bimonthly period, which was but seldom for domestic consumers. In 1925, therefore, service charge of $1 was introduced and all water consumed billed at uniform rate of 12 cents per 100 cubic feet. Effect of this change was to reduce consumption 12 gallons per meter per day. Displacement type meters are used for sizes up to 2 inches and compound meters for larger services. Smaller meters are read every 2 months and larger, weekly. Extensive accuracy tests show that meters should be removed for testing at least every 5 years. By adoption of this policy in London, percentage of pumpage recorded on consumers' meters has increased from 58.7 in 1926 to 69.0 in 1933, representing increased annual revenue of $1.66 per meter; while average cost

of removing, testing, and repairing a meter is less than $1.50, or 30 cents per year over 5-year period.—*R. E. Thompson.*

Photo-Electric Instrument Signals Changes in Raw Water Turbidity. Eng. Contract Record, **49**: 441–2, May 29, 1935. Brief description of device known as Photo-Electric Turbidicator, manufactured by Wayne Automatic Relay Company, Fort Wayne, Indiana. Instrument is adjusted to degree of turbidity existing and any change which occurs is indicated by signal gongs and lights. Factors such as aging of photo-electric cells or amplifiers, minor current variations, carbonization of light source, and discoloration of glass tank through which water flows are compensated for by 2 non-technical operating adjustments.—*R. E. Thompson.*

Advantages of Diesel Engines for the Water Works Field. Eng. News-Rec., **49**: 259–60, March 27, 1935. In addition to low-cost operation and reliability, further advantages of Diesel engines include easy starting, clean-cut appearance, comparative quietness, and simple maintenance. For service of purely stand-by character, where operation is required for but few hours each week, the Diesel can not seriously compete with gasoline engine, owing to higher capital investment involved; but when used for longer periods, to carry peak loads, the much lower fuel cost of Diesel engines offsets this disadvantage.—*R. E. Thompson.*

How Activated Carbon is Working out in Practice in the Water Works Field. F. E. Stuart. Eng. Contract Record, **49**: 265–7, 1935. Average requirement of activated carbon for taste removal is from 12 to 24 pounds per million gallons. Best practice is to pre-chlorinate and to add 5 to 10 pounds of carbon in mixing chamber and then 4 to 16 pounds to filter influent. Carbon may be applied with any type of dry or solution feed equipment. It is readily mixed with alum, best in proportion of 8 pounds to each 200-pound bag. Most satisfactory concentration for feeding through solution-feed orifice control box is 12 pounds, or less, per 50 gallons. Typical procedures from practice are outlined, including prechlorination, activated carbon treatment, filtration, and final ammonia-chlorine treatment. For algae control, advisability of heavy pre-chlorination appears questionable: dosages of 4 to 8 pounds have become recognised as most suitable for use in conjunction with activated carbon. When phenols are present, it is advisable to apply sufficient chlorine to convert phenol to chlorophenol, so that it can be more easily detected and removed before water is filtered and sterilized, thus obviating possibility of phenol passing through system and causing in final sterilization intensified taste which is sometimes uncontrollable with ammonia and chlorine.—*R. E. Thompson (Courtesy Chem. Abst.).*

Leakage in Long Pipe Line Found Small After Two Years' Service. Eng. News-Rec., **114**: 449, March 28, 1935. After being in service 2 years, 25-mile 36-inch cast iron pipe line from Ashland to Lincoln, Nebraska, was tested last fall in accordance with contract specifications. Original test by contractor

showed average leakage of 11.18 gallons per day per mile per inch diameter of pipe. Final test in October, 1934, by city, averaged 25.2 inch-gallons. Specifications allowed leakage not exceeding 100 inch-gallons.—*R. E. Thompson.*

Practical Value of a Water Works Control Laboratory. NORMAN J. HOWARD. Eng. Contract Record, **49**: 263–4, 1935. General discussion of part played by chemist in development of art of water purification.—*R. E. Thompson (Courtesy Chem. Abst.).*

Directory of Water Works Officials of Canada. Eng. Contract Record, **49**: 274–82, March 27, 1935. Directory of officials in charge of water supplies of cities and towns of Canada, which are listed alphabetically according to provinces.—*R. E. Thompson.*

Directory of Important Water Supply Systems of Canada. Eng. Contract Record, **49**: 283–98, March 27, 1935. Authoritative and up-to-date data, alphabetically arranged by provinces, concerning water supplies of leading cities and towns in Canada.—*R. E. Thompson.*

This Year's Water Works Prospects. A. E. BERRY. Eng. Contract Record, **49**: 257–8, March 27, 1935. In Ontario, there appears to be a somewhat encouraging trend in direction of increased water works construction programs. There are now 281 municipal water works in province, more than half being in municipalities of less than 2000 population and nearly 30 percent in centers of less than 1000 population. Combined assets of these works is well above 75 million dollars and annual revenue amounts to nearly 11 million dollars.—*R. E. Thompson.*

True Economy Demands Weighing Improvements Against Possible Gain. THEODORE A. LEISEN. Eng. News-Rec., **114**: 642, May 2, 1935. True economy may be defined as that method of operation, or construction, that will produce desired results with minimum of expense consistent with maximum efficiency. Economy, however, should not be confused with parsimony. Means of effecting economies are briefly discussed.—*R. E. Thompson.*

Five Years' Improvement of the Elastic-Wire Strain Meter. R. W. CARLSON. Eng. News-Rec., **114**: 696–7, 1935. Modified meter is made almost entirely of metal and uncertainties due to friction, temperature, and corrosion have been greatly reduced.—*R. E. Thompson (Courtesy Chem. Abst.).*

Operation of Kitchener Water Works. Eng. Contract Record, **49**: 205–6, March 6, 1935. Data from 36th annual report of Kitchener, Ontario, Water Commissioners, 1934. Consumption was practically equal to peak in 1929, average being 2.8 m.g.d., necessitating letting of contract for further well supplies of 1 m.g.d. at Strange Street and of 1.5 m.g.d. at Shoemaker Avenue. Owing to low expenses for maintenance and extensions, extra discounts averaging 22.5 per cent were allowed; entire profit, after meeting debenture charges, being thus returned to consumers. Financial statement shows assets of

$1,430,263.53, earned surplus of $232,563.71, and debentures outstanding $180,410.10.—*R. E. Thompson.*

New Equipment and Materials Aid Water Engineer's Task. THOMAS H. WIGGIN. Eng. News-Rec., **114**: 629–32, May 2, 1935. Review and discussion of progress in water works materials and equipment. Steel mains, 9 to 11.5 feet in diameter, lined with 2 inches of poured mortar, laid in New York about 1910 have nearly maintained original flow coefficient of 145 to 160. Bitumastic enamel coating on steel mains is in excellent condition after 15 years' service.—*R. E. Thompson.*

San Francisco Bay Pipe Line Crossing. Eng. News-Rec., **114**: 541, April 11, 1935. Unit prices given from low bids on alternative propositions (steel coated with gunite and cast iron with special flexible joints) for construction of double line of 54-inch submarine pipe line, 2800 feet long, across southerly arm of San Francisco Bay at Dumbarton Strait.—*R. E. Thompson.*

Journal of the New England Water Works Association, Volume 49, No. 2, June 1935. Pumping Water: an Historical Review. WALTON H. SEARS. 119–148. Ancient water supply systems relied chiefly upon man power aided by ingenious devices as jantu, sweep, noria or giant water wheel, chain of pots, and chain pump. VITRUVIUS (1st Century B.C.) gave first known description of pump. CTESIBIUS utilized levers operated by cams on shaft of water wheel for raising pistons, embodying in simple manner essential elements of single-acting, duplex power pump, including use of air chamber. First pumps applied to public water works, in 16th century, were driven by water wheels. Work of NEWCOMEN on pumping engines was instrumental in WATT's development of modern steam engine, which revolutionized pumping machinery. While backward people still retain ancient devices, this country has generally adopted centrifugal pumps, with electric, Diesel engine, or steam turbine drives, for new installations. Diesel engines are used increasingly in sizes under 400 h.p., where it can compete with other prime movers. **Taste and Odor Control in Public Water Supplies.** JAMES M. CAIRD. 149–151. Brief discussion of conditions causing taste and odor, including specific remedies which have been successful with certain water supplies, viz.:—for sulphite wastes, super- and dechlorination, or ammonia-chlorine; for algae, copper sulfate applied to reservoir; for phenol, potassium permanganate. Excess chlorine may be removed with sodium thiosulfate, or with sulphur dioxide. **Taste and Odor Control in the Small Plant.** R. G. YAXLEY. 152–155. At Waterford, N. Y., water is loaded with products of vegetable growth in swamps and shallow ponds, in addition to sulphite waste from paper mills, which combine to cause disagreeable, grassy, or woody, taste and odor. Pre-chlorination, with and without ammonia, permanganate of potash, sodium aluminate, activated carbon, and sulphuric acid for pH correction have produced little improvement. Best results, with highest quality basin effluent, have been attained through proper baffling. **Control of Tastes and Odors in the Water Supply of Rockport, Mass.** G. C. HOUSER. 156–161. Since 1922, Cape Pond, source of water supply, has been treated with dosage of 0.3 to 0.7 p.p.m.

copper sulfate one to four times a year, to control microörganisms causing taste and odor. In one treatment, Tabellaria was practically eliminated. Failure to decrease total number of organisms during past few years suggests that copper sulfate may have developed strains of resistant organisms. **The Betterment Assessment Method for Financing Water Main Extensions.** SYDNEY R. WRIGHTINGTON. 162–169. Old method of guaranty bonds for insuring revenue on water-main extensions was continued for 12 years following enactment of General Laws, although considerable trouble was experienced collecting deficit. Betterments are now assessed, and if not paid, added to next tax bill. **The Action of Water on Materials for Service Pipes.** F. WELLINGTON GILCREAS. 170–175. Chemical composition of water determines its corrosive action. Soft water, high in color and low in pH value, with CO_2 and organic acids present, exerts marked solvent action on lead pipe, in extreme cases causing plumbism among consumers. Acid water dissolves zinc from galvanized pipe, exposing iron to rust and resulting in red water and, possibly, disagreeable metallic taste. Ordinary brass is also affected, but admiralty metal and red brass are highly resistant. Although it adds to hardness, lime is most effective agent for treating pipe. **Freezing and Thawing of Water Mains and Services.** ALBERT A. ROSS. 176–181. Electricity and steam are used to thaw frozen water mains in Lexington, Mass. Precautions against freezing include proper installation below frost line, inspection by special service crews, consumer education, and maintaining continous circulation through elimination of dead ends. **Roadside Water Supplies.** ELMER W. CAMPBELL. 182–186. Since 1927, Maine has licensed all types of roadside eating houses, camps, tourist homes, etc., and inspection service includes description of water supply. Safe water being requisite for obtaining license, extension of public water systems has resulted in many cases, to replace polluted wells. Water supplies deemed unsatisfactory through inadequate protection against pollution, or excessive bacteria, or *B. coli*, content, dropped from 10.8 per cent in 1928 to 3.3 percent in 1932. **Slow Sand Filtration Plant, Newburyport, Mass.** PAUL F. HOWARD. 187–199. Peculiar condition of supply from ground-water and surface water sources in which former may vary from 40 to 100 percent of the whole, led to rejection of rapid sand filters in favor of 2-m.g.d. slow sand plant, to supply population of 15,000. Filters will remove sufficient iron and color and will not require services of experienced chemist. Filtered water basin has capacity of 500,000 gallons. Provision was made for future aëration. **Responsibility of Water Utilities for Collapse of Hot Water Boilers Resulting from Pressure Drop in Main.** WILLIAM F. SULLIVAN. 200–205. Boilers provided with temperature, pressure, and vacuum relief valves are reasonably free from failure; but some units built to withstand internal pressure of 200 pounds per square inch may collapse under a few inches of vacuum. Fortunately, collapsed boilers usually resume their shape when pressure is returned. As pressure drop is caused by broken main, closed pipe, or meter trouble, water company is not morally, or legally, responsible. Illustrations of laboratory test on boiler are included. **Completing Second 48-Inch Force Main, New Bedford, Mass.** STEPHEN H. TAYLOR. 206–211. Present supply to city depends upon 48-inch asphalt-coated, riveted, steel force main, $\frac{5}{16}$-inch thick, put into service in 1899 and now showing evidence of internal tubercula-

tion and pitting. Second 48-inch cast-iron main was started in 1921, but progress halted in 1932, with 4 miles completed; the last 9000 feet being lined with bitumastic enamel. Federal funds made possible completion of last 19,000 feet with steel-cylinder reinforced concrete pipe. **Manufacture and Construction of 48-Inch Lock-Joint Pipe Line, New Bedford, Mass.** F. F. LANGLEY. 212–220. Pipe consists of welded steel cylinder having joint-rings welded to its ends, surrounded by a cage of reinforcing bars; entire steel structure being encased inside and out in envelope of dense concrete, to form finished pipe of 12 foot laying length. In design, unit stress of 12,000 pounds per square inch was fixed upon as limit for normal operation, with 20,000 as maximum for surge conditions. **Chlorination of 48-Inch Pipe Line, New Bedford, Mass.** ERNEST J. SULLIVAN. 221–224. Portable chlorinator of 42-pound per day capacity was used to inject dry chlorine gas into water. Dosage of 10 p.p.m. was found adequate for proper disinfection. Residual was 2 p.p.m. after 24 hours, 0.10 after 72 hours. Line was thoroughly flushed before being put into service.—*T. F. Donahue.*